A Summary of Current Program and
Preliminary Report of Progress

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TRANSPORTATION AND STORAGE RESEARCH

of the
United States Department of Agriculture
and cooperating agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
December 14, 1962

OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit
Cotton and Cottonseed
Dairy
Deciduous Fruit and Tree Nut
Forage, Feed and Seed
Forestry
Grain
Livestock
Oilseeds and Peanut
Potato
Poultry
Rice
Sheep and Wool
Sugar
Tobacco
Vegetable
Economics
Farm Equipment and Structures
Food and Nutrition
Food Distribution
Home Economics
Soils, Water and Fertilizer

Two additional reports of programs are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities
Other Research -- Cross Commodity

ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

Agricultural Research Service (ARS)

Agricultural Engineering
Animal Disease & Parasite
Animal Husbandry
Crops
Entomology
Soil and Water Conservation
Utilization -- Eastern
Utilization -- Northern
Utilization -- Southern
Utilization -- Western
Human Nutrition
Clothing and Housing
Consumer & Food Economics

Agricultural Marketing Service (AMS)

Market Quality
Transportation & Facilities

Economic Research Service (ERS)

Farm Economics
Marketing Economics
Economic & Statistical Analysis
Foreign Development & Trade Analysis
Foreign Regional Analysis

Other Services

Farmer Cooperative Service (FCS)
Forest Service (FS)
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from W. C. Dachtler, Executive Secretary, Transportation and Storage Research Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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INTRODUCTION

This report deals with research on problems related to the storage and transportation of agricultural commodities and products. It includes work on costs and services, equipment and facilities and maintenance of quality during transportation and storage. Only a brief description of the related work of the State Experiment Stations and industry is included.

There is a statement describing the program of work underway and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort on transportation and storage problems is indicated by the approximate number of professional man-years employed: 70 by USDA, 85 by State Experiment Stations, and about 200 by industry and other organizations.

A brief report of progress and significant findings for USDA and cooperative programs is given for each phase of the research program.

Research by USDA

The research on costs and services comprises economic investigations on the impact of transportation on the marketing of agricultural commodities; the effect of transportation policy and regulation, rates, and costs and technology; loss and damage to agricultural products during storage and transit; motortruck operations and costs; alternative methods of handling, storing and transporting agricultural products, and improvement of operations for frozen food locker and related firms. This research is conducted by the Marketing Economics Division of the Economic Research Service and the Farmer Cooperative Service. In fiscal year 1962 it involved about 17 professional man-years.

Studies seeking to improve and better utilize storage and transportation facilities and equipment and to develop and evaluate more efficient loading methods are carried on by the Transportation and Facilities Research Division of the Agricultural Marketing Service. This research involved about 29 professional man-years in fiscal year 1962.

Research to maintain the quality of foods and other agricultural products during handling, packaging, storing and transporting is done by the Market Quality Research Division of the Agricultural Marketing Service. About 31 professional man-years were devoted to this work in the 1962 fiscal year.

Research by State Experiment Stations

There is included under each problem area a brief and very general statement on the nature of the research being conducted by the State

Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research.

Consolidating this information for the entire field of interest, we find that in fiscal year 1962 a total of 85 professional man-years were spent by the State Agricultural Experiment Stations on transportation and storage research. Transportation and storage research in 1962 was in progress in most of the 53 State Agricultural Experiment Stations. Studies underway were carried out by workers in departments of Agricultural Engineering, Agronomy, Animal Science, Chemistry, Economics, Food Technology, Home Economics, Horticulture, and Poultry.

The market quality phase of Station research deals with a number of physical and biological problems which are encountered in marketing citrus and subtropical fruits (14 man-years); deciduous fruit and tree nuts (16 man-years); livestock and meats (8 man-years); poultry (6 man-years); and vegetables (24 man-years). Station market quality research totaled 68 man-years in 1962. It is directed to determination of harvest maturity, precooling, physical changes that take place in cold storage, moisture loss and packaging, and storage temperatures for the commodities mentioned.

The State Experiment Stations devoted 17 professional man-years to the economics of transportation. Most of this research is oriented toward movement of commodities, particularly grains, feed, livestock, and livestock products. There is currently considerable research interest in commodity flows between surplus and deficit areas of the nation. This research holds promise of finding ways of reducing cross hauls and directing products to markets in a more logical and economical fashion.

No details on progress of State Station research are included in this report except as such work is cooperative with the Department.

Research by Industry and Other Organizations

The 200 professional man-years estimated for calendar year 1961 as industry's participation in research on storage and transportation problems are employed primarily by equipment manufacturers, engineering and construction firms, manufacturers of building materials and components and chemical companies.

A number of manufacturers of refrigerator cars and truck-trailer bodies are engaged in the developmental research of vehicle design, thickness and placement of insulation materials in walls and ceilings and air circulation by means of floor racks and channels. Machinery manufacturers are analyzing the efficiency of equipment used for loading and unloading rail cars and trucks seeking to improve their materials handling equipment.

Box manufacturers are engaged in the development of pallet boxes suitable for use in palletizing shipments of fruits and vegetables.

Engineering and construction firms are concerned with studies of layouts, designs, and other related facility problems for handling and storing. Manufacturers of refrigeration equipment, insulation, and related building materials devote a considerable part of their research and development time to problems of maintaining and controlling temperature and humidity conditions in storages and in conditioning and ripening rooms for fruits and vegetables.

Builders of storage facilities and manufacturers of prefabricated buildings maintain research laboratories which are used for testing components of buildings as to their suitability for use as grain storage facilities. Some of these tests include basic studies of structural load problems.

Research by chemical companies is directed toward the improvement in the formulation of insecticides and on materials to control decay and diseases of fruits.

Industry's cooperation in supporting research on problems of storage and transportation in the form of grants, gifts or loans of materials, equipment, and facilities at Federal and State Stations has contributed greatly to its success.

No details on progress of industry research are included in this report except as such work is cooperative with USDA.

I. TRANSPORTATION AND STORAGE COSTS AND SERVICES

ECONOMICS OF TRANSPORTATION AND STORAGE

Marketing Economics Division, ERS

Problem. Four billion dollars are spent each year for transporting farm food products for human consumption. This does not include charges paid for transporting feed, fiber, and farm production supplies. Neither does it include payments to move these products to foreign markets nor amounts paid to move farm supplies to the farms. No one knows what these payments all add up to; but if they amount to $5 billion annually, and 2 percent of this amount could be saved through better transportation, this would save shippers $100 million every year. This saving, if it could be made, would benefit farmers and consumers through higher prices for producers or lower prices to consumers or both. These benefits would mean higher net farm incomes. Conversely, an increase of 2 percent in the aggregate transportation bill would adversely affect net farm income.

Economics of transportation--as related to farm products and supplies--is concerned with learning how farm products and supplies move from place to place and with finding ways to move them better--for less money.

Transportation economics is also concerned with the revenue requirements of the carriers. Their revenues must be adequate to enable them to provide the kind of transportation services needed by shippers. This means that the carriers' revenues must be sufficient to encourage them to finance new capital improvements as well as to meet operating and maintenance expenses.

The charges shippers pay and the costs carriers bear are directly affected by the Nation's transportation laws. Economic research can be used to forecast the probable effect of proposed changes in laws. Research helps industries, public policy makers, and others to make better decisions.

USDA PROGRAM

The Department conducts a continuing program of research relating to the economics of transportation involving ten professional man-years. Research is conducted at Washington, D. C.; Bozeman, Montana; Manhattan, Kansas; and College Station, Texas.

A. Impact of Transportation on Marketing

Economic surveys are underway in the following areas:
1. Transportation of grain and grain products to, within, and from the South (in cooperation with the Southern Regional Grain Marketing Technical Commit-

tee); transportation of grain in the Northwest; grain transportation system in the Southwest (contracted, Agri-Research).
2. Transportation of fresh fruits and vegetables from California and Arizona.
3. Transportation of agricultural products by air freight.

These surveys are designed to:
1. Discern current modal and directional transportation patterns.
2. Evaluate the economic effects of these trends upon the various segments of the marketing system.

3. Provide USDA and industry with guidelines for future research.

The grain transportation surveys outlined above, together with completed ones, provide geographic coverage for the continental United States except for the Middle Atlantic and Northeast portions.

The California and Arizona fresh fruits and vegetables survey is the first in a series of planned surveys analyzing transportation flow patterns and trends for all major producing areas.

B. Transportation Policy and Regulation

Three projects are underway, or planned, to determine operating characteristics of all types of trucking firms engaged in hauling agricultural commodities in interstate commerce.

One covers for-hire truckers engaged primarily in hauling exempt unmanufactured agricultural commodities. Another deals with trucking operations of manufacturers who own trucks for the primary purpose of collecting their supplies and of delivering their own products but, as an incidental part of their trucking operations, haul agricultural commodities for-hire for others. The third concerns carriers who are certificated by the Interstate Commerce Commission to haul commodities that are subject to that agency's economic jurisdiction but that also engage in hauling exempt agricultural commodities for-hire usually to provide payload on the homebound portion of round trips.

The above studies will provide information needed for a closer and more informed look into the economic effects of present and proposed transportation legislation and regulatory policy upon the Nation's agricultural marketing structure.

C. Transportation Rates

Rail freight rate indexes for major commodity groups have been computed by the Department for several years. The availability of published rail rate and traffic volume information makes calculations of these indexes possible. Comparable rate indexes for motor trucks, domestic inland waterway, and foreign ocean shipping are not constructed.

Motor truck transportation of exempt commodities is conducted at rates agreed to by shippers and carriers and data are not readily available for either charges made by the carriers for the service they perform or for the volume of traffic handled by these carriers. Preliminary plans are being made to collect truck rates.

Most agricultural traffic--both farm products and farm production supplies--moves over the inland waterway in bulk and at rates negotiated by the shippers and the carriers. The actual rates are not available.

Ocean rates for grain, the predominant agricultural commodity moving overseas, usually are negotiated for each individual shipment. Since this traffic moves by means of unscheduled service, rates reflect demand for service and supply of facilities and fluctuate freely depending upon factors relating to the charter (size of ship, auxiliary services included, time of charter, availability of cargo space, etc.).

Attempts have been made on an exploratory basis to calculate a weighted average rate of ocean freight rates for periods covering the past two years. This work has brought to our attention many complexities and inconsistencies with which we have been unable to deal. Much additional information on operating and transfer costs are needed before a sound basis can be established for analysis and comparisons of charges made for transportation service over alternative routings available for overseas movements of agricultural commodities.

D. Transportation Bill

The rail freight rate and traffic data described above plus estimates of similar data for motor trucks are used to construct the Department's annual estimate of the Transportation Bill for domestically produced food. This figure is calculated each year and is used by other governmental agencies and private groups as well as in the Department's analysis of the marketing margin. The bill is published annually in Agricultural Statistics, the Agricultural Outlook Charts book, and Marketing and Transportation Situation.

E. Transportation Costs

There is a growing need for reliable statistical and financial data on exempt for-hire truckers, for domestic inland waterway carriers and for ocean carriers. The collection of that information for motor trucks and for domestic inland waterway carriers should be on the basis of logical geographical regions. This information is necessary if the Department is to be in a position to compare the costs of operation of these carriers with costs of those carriers for which information is available (i.e. rail, regulated highway and water carriers) and to suggest less costly means of transporting farm products and supplies. Without rather detailed infor-

mation for each type of carrier, it is impossible to determine which type or combination of types can perform best the services needed by shippers of agricultural commodities and farm supplies to result in the most efficient marketing--both in terms of money paid by shippers for services needed and in terms of service itself.

F. Transportation Technology

The latest type of covered hopper cars is physically well suited for rail shipment of grain and grain products. A project to determine their economic competitiveness with presently used boxcars for shippers, carriers, and receivers is underway. A small project to keep abreast of air freight developments is underway and will be continued.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

A. Grains and Feeds

Eight Southern States and USDA are conducting regional study SM-11, Transportation of Grain and Grain Products in the South, in order to determine the costs, volume, and direction of flow by different modes of carriage and needed changes in transportation of grain and grain products within, from, and to the South, especially as they are related to temporal and geographic price patterns, utilization, and storage. Each is a deficit State or consumes more grain during the course of a year that it produces, but each has local areas with temporary surplus at harvest time causing sharp seasonal price declines. The determination of proper location for storage facilities and processing plants requires careful scientific study of a number of factors.

Five grain-producing States (Ohio, Minnesota, Indiana, Oklahoma and Wisconsin) have been conducting studies under a regional project, NCM-19, Pricing and Trading Practices for Grain in the North Central Region, on truck transportation of grain and its effect on grain movements, pricing, and costs; changes in transportation of grain and its impact on marketing channels, pricing policies, etc.; the economic implication of recent highway and seaway developments on the operation of grain and supply agencies, location of grain facilities, and costs. These States and the Southern group freely exchange information obtained.

Massachusetts is concerned with the structure and relationship of freight rates on feed to poultry feed prices in the East. Oregon has been studying sources and methods of obtaining grain and reporting truck movements of grain and learning the classes of wheat being milled into flour.

B. Livestock and Livestock Products

Regional research is currently being conducted on the economics of transportation of livestock and livestock products in the Southern, Western and North Central regions. The research projects in this area represent well

integrated and coordinated State contributions to two regional research projects. In the South, with seven States participating, SM-23, An Analysis of Livestock and Meat Movement in the Southern Region, involves a study of meat and livestock movements which takes into consideration volume, direction and seasonal variation in movement, inefficiencies in movement, and the role of transportation costs and their implication upon the location of production and processing facilities. In the West, eight States are participating in regional project WM-37, Economics of Transportation of Livestock and Meats in the Western Region. This is concerned with an examination of the structure of rail and truck rates which prevail in the movement of livestock and meats, the equity of rates on inter- and intra- State movements, the costs and efficiency of shipping livestock and meats by truck and rail, and the effect of transportation costs on location of production areas and processing centers. Progress is being made toward combining forthcoming results of research in the South and West on the transportation of livestock and livestock products, with similar research to be conducted in the North Central region with perhaps some Northeastern State stations cooperating. In addition to the above, the Missouri station is making an analysis of rail and truck transportation costs for interregional shipments of livestock and meats, and Nevada is conducting research on controlled experiments in shrinkage resulting from transportation of cattle and sheep, and the cost of regain.

C. Poultry and Eggs

One northeastern station has been assigned major responsibility for regional poultry and egg marketing project NEM-21, Adjustments Needed in Marketing Northeastern Poultry Products. This study relates to the impacts of feed and poultry product transportation rates and costs on the relative competitive situation of the poultry industry of the region.

D. Economic and Technological Research

Most of the economic research by the transportation industry is related to the particular problems of individual companies in protecting their traffic or attracting new traffic. Relatively little economic research effort is devoted to national transportation problems or the overall transportation system of the country. The industry does give some financial support to transportation economics research through the universities and through carrier organizations. The research by shipping organizations and trade associations is mainly for purposes of opposing or supporting proposals which effect their specific competitive positions. Numerous segments of the agricultural community rely completely on Department economic research for information and recommendations regarding transportation.

In the field of technological research, the railroads rely heavily on suppliers of equipment. The adaptation of improvements is slow, partly due to the absence of economic evaluation by the carriers. Such evaluation by the Department frequently points the way to economies, ratewise or servicewise, for the

movement of agricultural commodities. This does not apply to other types of transport to the same degree, but there are numerous areas of untouched research potential where the Department's efforts can and do bear fruit. Estimated annual expenditures are equivalent to approximately 5 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Highway Transportation

1. Highway Carriers Engaged Primarily in the Business of Hauling Exempt Agricultural Commodities. A preliminary analysis of responses to mail questionnaires and of personal interviews of motor carriers engaged primarily in hauling unmanufactured agricultural products in interstate commerce indicates that operators in this economically unregulated segment of the transportation industry are a relatively stable group. Our preliminary analysis shows that even though many entering this type of for-hire motor trucking do not survive, once established they tend to stay in business for considerable periods. Responses indicate that more than one half of the established ones have been in business for more than ten years. Over 15 percent had been in business for more than 25 years.

Information collected also demonstrates that the economic and geographic freedom these carriers enjoy has enabled them to supplement regulated rail service and to benefit agriculture. The 1960 data show that they are active in all parts of the country and that they haul predominantly grain, perishables, and livestock. Many of these operators combine motor trucking with farming. Some act as brokers for shippers and other carriers. For this service they collect a fee. The transportation services provided by these carriers clearly seems to be necessary and unique in that they report that their principal competitors are other motor carriers like themselves rather than rail or waterway carriers.

2. Operating Costs of For-hire Carriers of Exempt Agricultural Products. A pilot survey of twenty-five highway carriers operating in Virginia, Delaware, and Maryland leads to the tentative conclusion that for-hire motor truckers who engage primarily in hauling unmanufactured farm products are able to provide service to shippers for considerably less than regulated carriers. Our preliminary summary shows that charges made for services provided by these carriers are in the neighborhood of 10 percent lower than those available to shippers for regulated carriers.

3. St. Lawrence Seaway Transportation. A broad program is underway to measure the impact of the improved Great Lakes--St. Lawrence Seaway--on marketing of agricultural products. Preliminary findings indicate that changing shipping patterns on the Seaway may cause total tonnage by 1968 to fall short of expectations by some 20 percent. Among the major bulk com-

modities grain, and perhaps iron ore, will likely dominate future Seaway traffic.

Agricultural commodities constituted 42 percent of the 11.8 million tons of Seaway traffic in 1958, 38 percent of the 20.4 million tons of traffic in 1959, and 43 percent of the 20.3 million tons of traffic in 1960.

4. Air Freight Transportation. The principal air freight carriers are being surveyed annually to determine the kinds and quantities of agricultural commodities hauled by them. More than 26,000 tons of agricultural commodities were moved by five major airlines during 1961. This was a substantial increase over the amounts moved in 1959. Principal commodities handled by volume were cut flowers, fresh fruits, vegetables and horticultural products.

Published air freight rates and carriers' costs are studied with a view to comparing these data with comparable data for surface carriers. Air freight rates averaged about 20 cents per-ton mile in 1961--about the same as rail express. Truck rates were about 6 cents. Many airline officials believe that new turboprop planes designed for cargo and the use of improved ground handling facilities will reduce costs to 15 cents per-ton mile or less in the near future if the volume of traffic increases and if the available plane capacity is more fully utilized.

REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Highway Transportation

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TRANSPORTATION OPERATIONS OF FARMER COOPERATIVES
Farmer Cooperative Service

Problem. Farmers look to their cooperatives to provide them with adequate transportation at low cost. There is need to develop methods for reducing product losses in transit; to explore alternate methods of handling and transportation; to improve utilization and efficiency of traffic management services; and to determine costs, scope of operation and economic importance of privately operated motor trucks, if farmer cooperatives are to meet the transportation requirements of their members.

USDA PROGRAM

The Department has a continuing long-range program of basic and applied research and technical assistance to help farmers develop and maintain efficient cooperative transportation services. Studies are made on transportation methods and costs.

The work which is centered in Washington, D. C., involves 3.6 professional Federal man-years. Many of the studies, however, are conducted in cooperation with various State Experiment Stations and Extension Services, and Departments of Agriculture.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations currently have no work directly on transportation problems of farmer cooperatives. However, they are giving considerable attention to the adjustments in organization which cooperatives must make in view of recent and prospective changes in market structure.

Traffic and transportation departments of several farmer cooperatives are engaged in motortruck operating cost studies and studies of alternative methods of product handling and transportation. Estimated annual expenditures are equivalent to approximately 3 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Loss and damage to agricultural products in transit. Farmers and their marketing agencies incur millions of dollars of loss each year due to damage and loss associated with the movement of agricultural products from producing areas through the marketing process to final destinations. Such losses must be borne, in part, by one or more segments of the industry.

Studies of livestock loss and damage in transit were completed and three reports of findings were released during the period. Principle findings of a study of loss and damage in handling and transporting hogs include: (1) Loss and damage to hogs associated with handling and transportation in marketing and processing are estimated to be $22.6 million a year; (2) the largest loss due to bruising was in hams, followed by bellies and shoulders, in that order; and (3) truck losses exceeded rail losses by $8.07 per hundred head.

Principal findings of a study of losses from handling sheep and lambs are: (1) Losses occurring at the market level during transporting and handling sheep and lambs amount to almost $2 million a year; (2) abusive handling was a principal contributor to loss and damage; and (3) improving the handling of sheep and lambs during marketing and processing could reduce loss and damage and result in increased income to the various segments of the industry.

A report outlining methods for safety-checking handling facilities to reduce livestock losses was published. According to the report, factors to be considered in evaluating a livestock handling facility include: (1) Weather; (2) species of animal; (3) capacity of facility; and (4) handling personnel. Methods for evaluating the physical makeup of the facility including condition and design of railings, fences, alleys, pens, chutes, docks, gates, scales and feeding facilities are included in the report.

Detailed data have been collected on 10,000 cars of grain covering a 2½-year period from 75 country and 6 terminal elevators regarding loss and damage in transit. Data on loss records and equipment are also being assembled on barge shipments of grain from eight grain elevators located on the inland waterways.

Motortruck operations and costs. Little information is available on costs, scope of operations, services and economic importance of motortrucks operated by farmer cooperatives. The scope and extent of the movement of agricultural products by private motor carriers, including farmer cooperatives is one of the important remaining gaps in transportation statistics.

Preliminary findings of a study of 6,100 farmer cooperatives include the following: (1) Farmer cooperatives own or lease an estimated 33,000 motortrucks; (2) only 28 percent of the total truck mileage reported by the cooperatives involved hauls other than local pickup and delivery and movements from fields to local concentration points. Thus, the great majority of their truck operations are local in nature.

A report of findings was released on a study of advantages and disadvantages of motortruck leasing. The report also outlines general guides and principles to be considered by management of a firm in determining whether to lease or purchase motortrucks.

A compilation of State regulations pertaining to the intrastate operations of motortrucks by farmer cooperatives is nearing completion.

Appraisal of alternative methods of product handling and transportation. Changes in marketing and distributing methods for agricultural products have been accompanied by changes in demand for transportation and handling facilities and services.

Collection and analysis of data on a study to appraise possibilities of reducing wool transportation costs by analyzing alternative methods of transporting and handling wool and determining advantages of establishing wool baling and scouring facilities near the source of production are completed. A report of findings is being prepared by the contractor, Texas Transportation Institute, College Station, Texas.

Preliminary analysis indicates there are possibilities in specific areas for reducing transportation costs on wool by locating scouring facilities near the source of production. The report of findings will include detailed data on traffic flow patterns on grease and scoured wool, as well as comparative transportation costs and services. A suggested size standard for wool bales has also been developed as part of the study.

Traffic management in farmer cooperatives. Less than 300 of the over 9,200 farmer cooperatives in the United States have traffic departments. Yet, over 2 million farmer members of cooperatives depend on these associations to provide them with adequate transportation at low cost to maximize returns on farm products marketed.

A questionnaire was mailed to the over 9,200 farmer cooperatives. Over 6,000 farmer cooperatives replied to the questionnaire and indicated whether they had full or part-time traffic management service.

Preliminary findings based on partial analysis of data indicate the following:

1. Less than 10 percent of the cooperatives reporting had anyone devoting full or part-time to transportation management.

2. Only about two percent of the cooperatives had anyone devoting full time to transportation management.

3. There is a direct relationship between size of firm and transportation management. Two-thirds of the largest cooperatives reporting in the $10 million and above annual business category had full-time transportation management.

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IMPROVING OPERATIONS FOR FROZEN FOOD LOCKER AND RELATED FIRMS
Farmer Cooperative Service

Problem. Local locker and food processing plants are primarily organized to supply customer processing and locker storage for farmers. They lack essential information as to effective techniques in merchandising frozen foods and in providing services to home freezer users and other outlets. This type of merchandising is relatively new and guidelines are needed to aid these small firms in developing efficient merchandising operations. Also, management of frozen food locker and freezer provisioning firms need better information on modern management methods and on production control techniques, costs, and related management tools to aid in meeting changes brought about by expanded use of home freezers and reduced demand for locker service.

USDA PROGRAM

The Department has a continuing program of research to assist farmers in improving cooperative organization and operation of frozen food locker services. The work is centered at Washington, D. C., and involves 3.0 professional Federal man-years. Part of the work is carried out by contract with Iowa State University to develop methods and data needed by frozen food locker and related firms for improving facilities planning and product handling.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State Experiment Stations do not report any work dealing with frozen food lockers.

The National Institute of Locker and Freezer Provisioners and the Industry publication "Freezer Provisioning," occasionally conduct studies among the members of the Institute or subscribers to the trade publication to develop such information as customer attitudes and sales volume. Other studies, such as surveys of labor costs, are undertaken to develop information useful in evaluating the impact of wages and hours legislation on the industry. Approximately one-third professional man-years is devoted to this type research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Cost and Efficiency of Operations. Development of cost control techniques for frozen food locker and related plants: Adequate and appropriate accounting procedures for guiding management of small processing plants have been needed for many years. Under contract, Duke University has developed a management accounting system that sets

forth the more important cost areas of operation and techniques to control them. The system has been tested and found suitable for use in small processing plants.

Survey of facilities and operations of locker and freezer provisioning plants: A survey of the frozen food locker and freezer provisioning industry is made every five years to determine changes and trends. The 1960 survey showed an increase of 1.4 million patrons served; an increase of 200 million pounds of food processed; and a 100 percent increase in volume of frozen food sold. Total industry sales reached $845 million in 1959.

Developing methods and data frozen food locker and related small processing firms need for improving facilities planning and product handling: A contract has been signed with Iowa State University and the work is just getting underway.

An appraisal of facilities and operations of frozen food locker cooperatives: Cooperatives comprise between 5 and 6 percent of the locker and freezer provisioning industry. Locker cooperatives continue to emphasize custom services in contrast to the industry trend of more commercial processing and merchandising. This emphasis is reflected in sales which average about one-third the average for the entire industry.

Annual report of frozen food locker plants in the United States: This study provides basic information on the number of firms in the locker and freezer provisioning industry at the beginning of each year. At the beginning of 1961 there were 10,365 firms, an increase of 490 over the previous year. The increase is due to the increasing number of firms that are organized to serve homefreezer owners.

Merchandising Methods. Merchandising methods of frozen food locker and related plants: Merchandising is a broad area of growing importance to locker and freezer provisioners. Efforts were successful in compiling some needed information on four basic areas of merchandising -- credit, delivery, membership and advertising. This effort turned up other areas that needed investigation.

An appraisal of the influence of credit upon sales volume in locker and freezer provisioning organizations: Credit is a powerful merchandising tool. Locker and freezer provisioners extending installment credit had average sales of $163,400 compared with $85,500 for the entire industry. Companion work is underway to examine relations among cash sales, open account sales and installment sales in a limited number of firms.

Improving Product Handling and Operating Practices. The role and methods of locker and related processing cooperatives in processing and merchandising locally-produced food products: Need for this kind of study is great in light of the changing nature of the locker and freezer provisioning industry. The work is just getting underway.

Frozen food locker plants in a national emergency: This Branch has worked closely over the years with other Government agencies to provide them with information about the locker and freezer provisioning industry that would help them plan for any national emergency. Among these agencies have been Office of Price Stabilization, Office of Defense Mobilization, Office of Civil Defense, Office of Civil and Defense Mobilization, Office of Emergency Planning, Food and Materials Requirements Division, Commodity Stabilization Service, and Defense Services Staff, Agricultural Stabilization and Conservation Service.

General information on number of plants, location and processing and storage capacity has been furnished along with specific information on cubic feet of gross refrigerated space and standby power equipment. Information of this nature is provided each time a survey of the industry is made.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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II. EQUIPMENT AND FACILITIES FOR TRANSPORTATION AND STORAGE

TRANSPORTATION EQUIPMENT AND LOADING METHODS
Transportation and Facilities Research Division, AMS

Problem. The bill of several billion dollars per year for transporting farm and food products is of concern to farmers and consumers. Transportation costs are also of paramount concern to carriers, because carriers cannot insure their prosperity by raising rates. The principal objective of transportation research is to find ways to increase efficiency and to make the transportation system more responsive to changing needs. Improvement in the efficiency of transportation is needed by coordination of different forms of transportation. This means a greater coordination between rail and truck, truck and boat, rail and boat, and truck and air. Much of the transportation equipment now in use fails to give adequate protection to the more perishable commodities. Methods of loading often leave the container and product subject to mechanical damage in transit, result in poor utilization of available transportation equipment and hamper effective refrigeration. The substantial savings in labor costs incident to mechanized handling accomplished in other areas are not being realized in agricultural transportation. Studies of ways to improve transport equipment and methods of loading need to be accelerated in order that the potential savings to agriculture may not be longer delayed. In the field of air transport, provisions for efficient and economical handling to and from airports and protection against heat and cold are inadequate. These matters have been relatively unimportant up to the present time because of the low volume of products transported, due in turn to high transportation costs. Projected plans of airlines include cargo planes with operating costs approximately one-half of present levels. The new service at lower rates promises to attract a considerable volume of agricultural tonnage, raising the problem to one of importance. In the area of water transportation the arrival condition of fruits and vegetables due to inadequate refrigeration, container, and stowing problems has seriously affected the market for United States products abroad. A beginning has been made on the coordination of movements of agricultural products between the different modes of transportation but numerous problems of refrigeration, containerization, adaptability of bulk containers to commodity needs, and inefficiencies of handling between carriers need solution. Studies should also be made to determine how the new coordinated transportation services and equipment can best be adapted to the marketing of individual products so that maximum benefits can be realized.

USDA PROGRAM

This is a long-term continuing program aimed at improving the efficiency of the transportation system: Through improvement in the efficiency and utilization of equipment; through development and use of more efficient facilities; through improvement of services; through streamlining operations by development and adoption of better methods and practices including automation. Specific studies now underway include: (1) Improvement of transportation equipment, including but not limited to refrigeration; (2) improved utilization of transportation equipment; (3) better loading methods; and (4) development, testing, and evaluation of pallet containers and unitized loads.

The current program involves 14.7 professional man-years--1.2 program leadership; 2.0 heat transfer and air circulation; 2.0 improvement of specific features of rail and truck equipment; 2.1 performance of rail and truck equipment; 4.4 loading methods; and 3.0 palletized and unitized loading.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Equipment Manufacturers. A number of manufacturers of refrigerator cars and truck-trailer bodies are engaged in the developmental research in vehicle design, thickness and placement of insulation materials in walls and ceiling, and air circulation by means of floor racks and channels. Several machinery manufacturers are analyzing the efficiency of equipment used for loading and unloading grain, feed, and flour in rail cars and trucks. Another equipment manufacturer is developing new types of grooved flooring and synchronized power lifts which make possible unitized loading of both rail cars and truck-trailers. The results obtained by these companies are kept confidential. The estimated annual expenditures for research in these areas are equivalent to approximately 10 professional man-years in improved design of refrigerated rail cars; 15 professional man-years in improved refrigerated trucks; 5 professional man-years in development of loading and unloading equipment; and 5 professional man-years for development of unitized loading equipment. Manufacturers of materials handling equipment used for loading and unloading cars, as well as for many other purposes, maintain a continuing program of developing improvements in their equipment, but the extent of this research is not known.

Container Manufacturers. A number of box manufacturers and their associations are engaged in the development of pallet boxes of sizes, strengths, and types of construction suitable for use in palletizing shipments of fruits and vegetables. Estimated annual expenditures are equivalent to approximately 10 professional man-years.

Food Processors. Two processors of baby foods in California are testing the adequacy and efficiency of several types of containers

and of alternative handling methods for palletized shipments of western pears from point of production to their plants. The companies carry on this work to solve specific problems associated with their plant operations and results are kept confidential. Estimated annual expenditures are equivalent to approximately 1 professional man-year.

Virtually all of the AMS research work in this area is done with industry cooperation or participation. During the past two years the Transportation Research Branch had active cooperation in its projects with 12 trade associations, 27 equipment manufacturers, and 12 industries of allied nature, as well as many shippers and receivers of agricultural products. In some cases cooperation took the form of assistance in arranging transportation tests, in others the furnishing of equipment and facilities necessary for the test program. In one instance the Truck Body and Equipment Association contributed $23,000 toward a research project for the improvement of trucks for the transportation of frozen food. Industry personnel took part in a number of transportation tests.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Heat Transfer and Air Circulation

1. Truck Rating. Work on the rating method for refrigerated delivery trucks is continuing at the National Bureau of Standards. Four truck bodies have thus far been tested for heat gain, moisture weight gain, and air leakage, using a metering heat sink apparatus. Test conditions are 0° F. interior temperature and ambient conditions of 100° F. temperature and 50 percent relative humidity.

An apparatus has been developed to simulate the effects of sun on the heat transmission rate of insulated bodies. One of the trucks was subjected to a solar test and results show that solar radiation significantly increases heat transmission.

A helium trace apparatus was also developed to measure the amount of warm air that enters the body during door openings such as occur when frozen foods are delivered at each retail store. Tests were made at temperatures of 0° F. interior and 100° F. ambient. The difference in density of air at these temperatures caused an inward flow at the top and an outward flow at the bottom of the door. It appears that there is a short period of accelerating flow followed by a gradual decrease as the temperature in the truck rises.

2. Trailer Cold Air Circulation. Work at the National Bureau of Standards during this reporting period covered study of the effect of cyclic operation of the refrigeration equipment. Initial tests were made with the point of temperature control located in the return air

to the refrigerating coil. Tests in progress at the end of the reporting period include investigations under the following conditions:

a. Free air discharge over load.

b. Return air admitted to refrigerating unit compartment through side wall vents and floor vent and with the trap doors above load closed.

c. Refrigerating unit control in return air to cooling coil, set for 4° F., 6° F., and 12° F. nominal differentials and with the cut-on temperature at 0° F. in each case.

d. Cyclic operation of refrigerating system with continuous blower operation and with simultaneous cyclic blower operation.

Data will be analyzed to determine optimum location of temperature control, the preferred method of cyclic operation, the rate of temperature change and total temperature change in the cargo and in the air surrounding the cargo, and the effect of frost accumulation on the cooling coil. Calibration of thermocouple-type anemometers designed for and used in these tests was verified and a means was found to overcome probe sensitivity to air temperature. All probes will be modified the next time the load is moved.

B. Improvement of Specific Features of Rail and Truck Equipment

1. CO^2 Refrigeration. A large manufacturer of carbon dioxide (CO^2) has put on the market a liquid CO^2 refrigerating unit for use on truck-trailers. There is much interest in this unit and a test was conducted by USDA to evaluate its performance. In August 1962, the CO^2 trailer and a trailer with conventional mechanical type refrigeration were compared on a "piggyback" trip from Pueblo, Colo. to Philadelphia, Pa. Both trailers were loaded with frozen meat. Preliminary analysis of results indicate that CO^2 does not compare favorably with mechanical refrigeration. During the 7-day period from loading at origin to unloading at destination, the following was found:

a. The mechanical unit used about $16 worth of diesel fuel and the CO^2 unit used over $200 worth of liquid carbon dioxide.

b. The mechanical unit used approximately 70 gallons of diesel fuel out of its 100 gallon tank and did not need refueling enroute. The CO^2 trailer was recharged 6 times during the same period with over 7,500 pounds of liquid CO^2. Railroads are continually striving to reduce the time required for servicing of cars and trailers enroute. Use of CO^2 refrigeration would seem to be a move in the opposite direction.

2. Salt-Ice Car. Three cars have been tested in a laboratory under controlled ambient temperature conditions using various ice salt mixtures. Two cars had internal air circulating fans and the other one did not. The following temperatures were achieved after 12 or more hours of testing in the fan cars with the fans operating continuously throughout the test: Pure ice, 36.5°; 5% salt, 28.5°; 10% salt, 18.5°; 15% salt, 18.0°; 20% salt, 14.0°; 25% salt, 13.9°; 30% salt, 13.9°. Correspondingly, in the non fan car the following car temperatures were achieved: Pure ice, 38.5°; 5% salt, 26.6°; 10% salt, 25.5°; 15% salt, 22.9°; 20% salt, 20.2°; 25% salt, 21.7°; and 30% salt, 18.0°.

Generally the car cooling rate was proportional to the ice melt rate. The ice melt rate increased as the percentage of salt was increased. As the car temperature dropped in each test the ice melt rate and cooling rate also decreased. The amount of ice in the bunker was especially critical at the greater salt concentrations in order to maintain the low temperatures. As the ice melted at a faster rate at the higher percent salt concentrations the amount of ice in the bunker dropped rapidly and the ability to maintain the minimum temperature was soon lost, and rising temperatures resulted.

The advantage, therefore, of salt concentrations greater than 20% is not sufficient to warrant use except where fast pulldown is necessary, where frequent re-icing is available, or where a maximum of cooling capacity is necessary.

C. Performance of Rail and Truck Equipment

1. Perimeter-Cooled Trailer. A new type of trailer known as the perimeter, or envelope type has been developed in which cold air is circulated around and under the load. This method is a result of a design developed and recommended by a staff member of the Transportation and Facilities Research Division. Two over-the-road tests were made to evaluate the performance of this trailer design. In the first test, a 4-day 2,100 mile over-the-road test, the perimeter trailer had an average frozen food temperature of -2.5° F. during the trip and -3.4° F. at destination. In a second over-the-road test the perimeter trailer had an average frozen food temperature of +2.4° F. during the trip and 0° F. at destination. The conventional trailers had an average frozen food temperature of 8.2° F. during the first test and 8.5° F. at destination, and in the second test had an average temperature of 10.1° during the trip and 13.8° F. at destination. The conventional trailers are now being replaced by the cold-wall trailers in the fleet operated by the cooperating company. They believe the improved performance of the design outweighs the disadvantage of the loss of some 10 percent of the trailer's capacity.

2. Liquid Nitrogen Refrigeration. There have been no significant findings since the last report. There are still only a very few companies that are trying out liquid nitrogen refrigeration in trucks and trailers. The originator of the liquid nitrogen refrigeration system now has competition which could lead to improvements and lowered costs.

3. Fresh Lamb by Rail. A test was conducted on four loads of freshly killed lamb moving by railroad from Pueblo, Colo., to Philadelphia, Pa. The vehicles used were:

a. Refrigerator car with mechanical refrigeration.

b. Refrigerator car with ice bunker and continuous air circulation.

c. Piggyback trailer with mechanical refrigeration, no air ducts.

d. Piggyback trailer with mechanical refrigeration and air ducts.

There was some variation in temperatures throughout the cargo in each vehicle but the lamb was in very good condition at destination. Temperatures in the four vehicles were generally alike during the trip, but in-transit shrinkage of the loads varied from 0.55% to 2.2%. Results of this test indicate that each of these different types of vehicles can maintain satisfactory temperatures. However, shrinkage could probably be reduced by changing the pattern of air circulation around the cargo.

D. Loading Methods

1. Improved Loading Methods for Truck Shipments of Apples in Corrugated Fiberboard Containers. All field work on this project was completed about two years ago. The initial results of this research were summarized in an interim report, AMS-321, entitled, "Loading Methods for Truck Shipments of Apples in Fiberboard Boxes," released in July 1959.

This work involved the informal cooperation of the Maine Department of Agriculture, the Maine Agricultural Experiment Station, several New England apple shippers, three chain stores, a large truck line, adhesive manufacturers and various other concerns. The interim report described the new "air-channel load" developed in the initial phase of this work and reported on its comparative effectiveness in reducing load disarrangement, container damage and in facilitating more effective refrigeration in transit. Subsequent work described in the final report on this research now being readied for publication centered on the development of improved load securing methods, and materials, including load-locking devices, bracing frames and a frictionizing coating applied to the outside surfaces of the boxes to

assure that each container in the new "air-channel load" would remain in place during transit.

2. Improved Loading Methods for Truck Shipments of Potatoes. This work, which has been underway for the past three shipping seasons, has resulted in the development of two new loading patterns; one for 50-pound multiwall paper bags and one for 100-pound burlap bags. Formerly, bags of both sizes were stacked in a compact mass in the interior of truck trailer vans in such a way that the incoming outside air in ventilated shipments could not penetrate the main body of the load for removal of excess heat and moisture from shipments of early and mid-season potatoes. The new loading patterns for both sizes of bags, which can be used at no increase in cost and at no sacrifice in load weight, contain continuous longitudinal channels for effective air circulation through the entire load during transit.

Almost a thousand copies of a loading diagram for the new pattern for 50-pound paper bags have been requested and distributed to shippers and truckers, many of whom are now making wide use of the new loading method. Research currently underway deals with measuring the comparative effectiveness of more and larger perforations in multiwall paper bags in the new loading pattern to facilitate better protection of the product in transit. An interim report on the initial results of this research is now being reviewed for publication.

3. Heavier Loading of Watermelons. If it is feasible to load watermelons heavier in all-rail and in rail-piggyback shipments than in conventional shipments, it will be possible to materially reduce the per-melon cost of transportation under per-car or per-trailer rates. To determine if this can be done, more than 90 test and control shipments of melons have been made during the past four shipping seasons from producing areas in Florida, Georgia, South Carolina, North Carolina, and Virginia. During the 1962 season, field work was completed with the shipment of 6 cars 7 layers high, 3 cars 6 layers, and 5 control cars loaded 5 layers high. Findings indicated that heavier loading of rail refrigerator cars is feasible when sound melons are used. However, it is not practical for shipment of overripe melons. Data for the past two shipping seasons shows that damage rates are about the same in 6-layer loads of sound melons as they are in 5-layer loads. The 7-layer loads, however, had somewhat more damage and loads of this height may not be practical in rail cars.

"Piggyback" service in transporting watermelons from southeastern growing areas to northeastern and midwestern markets was begun on a limited basis during 1962. Terminal market inspection of seven trailer loads showed that the watermelons, even when stacked 8-9 layers high, sustained substantially less damage than melons in rail cars.

Other preliminary tests indicated that a new cushioning material, expanded polystyrene plastic foam, may be superior to straw, hay, or

other conventional cushioning materials. Possible advantages are speed and ease of application; better air circulation; drier, cleaner melons on arrival at destination; and better melon protection.

Reinforced paper grain doors, which cost the same as the conventional wooden door boards, were tested with generally good results. The doorway retaining unit is a corrugated sheet with steel straps laminated between the face sheet and the inside flutes. This type of unit requires less time to install than the wooden door boards and it is flush with the sidewalls of the car, which helps reduce melon damage in the doorway area of the cars.

4. Improved Loading and Icing for Fresh Peas. Laboratory compression tests of several different types of bushel baskets were completed at the Forest Products Laboratory during the fall of 1961. During the 1962 spring season shipping experiments were made from California to eastern markets on the continuous stave baskets which the laboratory tests indicated were superior in some respects to the conventional solid bottom baskets. Shipping experiments also included a comparison of the crosswise offset alternately inverted loading pattern against the conventional bottom-to-bottom, top-to-top alternately inverted pattern. Both the continuous stave baskets and the crosswise-offset alternately inverted load were effective in reducing container damage in transit.

The 1962 season shipping tests also included 4 cars in which the amount of top ice applied at the shipping point was reduced from 22,000 pounds to 10,000 pounds and on which the amount of ice applied in transit was also reduced. Preliminary analysis of the data indicate that less top ice used in conjunction with half-stage bunker icing at origin will provide as effective refrigeration as the heavier amounts of top ice and at the same time help reduce container damage due to excessive overhead weight of the ice. This research has been carried out cooperatively with the Horticultural Crops Branch, Market Quality Research Division of AMS, the Forest Products Laboratory of the Forest Service, the Association of American Railroads, the American Veneer Package Association and the Railroad Perishable Inspection Agency. All field work on this project has been completed and a report on the research is now being prepared for publication.

5. Better Loading Methods for Onions in Bags. Onions packed in 50-pound open mesh bags are normally loaded in rather compact masses in rail refrigerator cars and trailer trucks for transportation. The loads are ventilated with outside air during transit, but because of relative tightness of the loads, much of the incoming air cannot reach the bags in the middle and lower layers of the loads. The increased use of heavier loading of rail shipments to obtain the advantages of lower freight rates in heavier loads has made the problem of providing adequate ventilation to the bags in the middle of loads more acute.

The product must be ventilated to remove any accumulation of heat and moisture which promote the rapid development of decay.

Four new loading patterns were developed for rail shipments and were tested on a limited scale in the relatively short shipping season for Texas onions during the 1961 spring shipping season. Results obtained for two of the new patterns were favorable while those obtained for the remaining two were not. The improved loading patterns, which contain vertical and horizontal passageways for the movement of the incoming air through the loads, were found to be relatively stable in transit and to provide somewhat lower commodity temperatures upon arrival at northern and eastern markets than the conventional tight-stacked loads.

Two additional test shipments were made during the year with the new pattern for truck shipments developed the previous year. Additional experience with this pattern confirmed its stability and effectiveness in providing lower commodity temperatures in transit than could be obtained in the conventional loads. Use of the new loading patterns for rail and trucks involves only different stacking patterns for the bags and will cost the shipper nothing for additional labor or materials and require no sacrifice in the size and weight of loads for transportation. However, additional work is needed to further refine the stacking patterns and to obtain more adequate measures of their stability and relative effectiveness in providing more favorable product temperatures.

No shipping experiments were undertaken during the 1962 shipping season because of the demands of other projects for available manpower and funds.

6. Loading Patterns for Truck and Piggyback Shipments of Citrus Fruit. Additional research done during the past two years on the new "air stack loading pattern" for corrugated fiberboard boxes has resulted in the development of further refinements of the new pattern. One of the improvements was the modification of the top layer which provides for 84 openings between the boxes in the top layer to permit the circulating refrigerated air to reach the channels in the main body of the load. This change was necessary for shipments made in late-model refrigerated trailers to prevent the cooled air from by-passing of the main body of the load by going down the sidewall flues and providing perimeter cooling only.

The new loading pattern has been adopted and is now used in several thousand over-the-road truck and rail piggyback shipments each season by about 500 Florida citrus shippers. The development and use of the new loading pattern which provides more effective cooling of the fruit shipped in the corrugated boxes has helped stimulate the increased use of these cheaper and easier-to-handle containers. This has resulted

in a savings of several hundred thousand dollars per year to Florida citrus shippers in container costs alone.

During the past two years rail piggyback services were made available to Florida citrus shippers and have been used quite extensively. Considerable work was done during this period to help the carriers and shippers solve some problems encountered in adapting the new equipment and service to the handling of citrus. The initial results of this phase of the work was summarized in a recently released interim report.

E. Palletized and Unitized Loading

1. Pallet Containers. Several test shipments of apples in expendable corrugated fiberboard pallet containers were made from Washington State to Minnesota chain store prepackaging plants during the past year. Data on comparative handling costs and fruit bruising were obtained to supplement that developed in previous work in this area conducted under contract by the Food Industries Research and Engineering. The additional information obtained in the tests has been integrated with that developed in previous work and a report on this research has been prepared for publication.

This work has shown that savings in shipping apples from Washington State to Minneapolis in pallet containers will amount to as much as $400 per car as compared to shipping them in the conventional 40-pound tray pack cartons. Savings are derived from lower container, packing, handling, transportation and protective service costs per pound of fruit transported. The pallet containers carried about 800 to 900 pounds of fruit and were loaded, unloaded and handled with fork lift trucks. Savings in transportation costs in rail shipments derived from lower freight costs because increased load density in pallet container shipments made it possible to ship more fruit per car.

During the past two years several tests were also made with pallet container shipments of oranges and grapefruit from Florida to northern markets. Although potential savings that might be derived from shipping these products in pallet containers as compared with shipping them in smaller conventional containers are not as large as in the case of apples they are still substantial. An interim report on this work is now being prepared for publication.

2. Unitized Loading. During the past year a new railroad piggyback trailer equipped with a modular-grooved aluminum alloy flooring to facilitate loading and unloading of unitized loads by the multi-fork system without pallet was made available to AMS for shipping and handling experiments through the cooperation of a major southeastern railroad, a trailer manufacturer and the flooring manufacturer. Only one test shipment of canned citrus juice was made with the new equipment and handling system late in the 1962 season. Although the system

appeared to work fairly smoothly in some respects, a few major difficulties were encountered. It is still too early to appraise the results of this exploratory work.

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STORAGE FACILITIES AND EQUIPMENT
Transportation and Facilities Research Div., AMS

Problem: Returns to producers and prices paid by consumers for agricultural crops are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods,techniques, devices, operating procedures, equipment, and facility designs are needed for conditioning and storing fruits and vegetables, grains, and other crops. Such improvements are needed at both shipping points and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

USDA PROGRAM

This is a continuing long-range program involving engineering research covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for conditioning and storing agricultural crops. The research is carried out at Washington, D. C.; Gainesville, Florida; Athens and Bainbridge, Georgia; Watseka, Illinois; Lafayette, Indiana; Manhattan, Kansas; Presque Isle, Maine; East Grand Forks, Minnesota; Beaumont and College Station, Texas; and Wenatchee, Washington, in both laboratory and commercially-owned facilities. State Experiment Stations and commercial firms and organizations cooperate in carrying out this work. The research involved 7.5 professional Federal man-years in fiscal year 1962, of which 2.5 man-years are devoted to storage work on grains, 1.3 to rice, 0.8 to cotton, 2.0 to potatoes and 0.9 to fruits.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

No work by State Experiment Stations is reported for this area.

Engineering and Construction Firms. New plant construction in the fruit and vegetable industry involves research by private architectural and engineering firms on layouts, designs, and other related construction problems. It is estimated that these firms devote an annual expenditure to this effort of approximately 50 man-years.

Manufacturers of Building Materials and Components. Manufacturers of refrigeration equipment, insulation, and related building materials devote part of their research and development time on the problems of maintaining and controlling temperature and humidity conditions in storages and in conditioning and ripening rooms for fruits and

vegetables. This group includes the manufacturers of thermostats, humidistats, and other electronic controls. Approximately 50 man-years per year are expended by these firms on the special application of their materials and equipment for fresh produce.

Contractors and Prefabricated Building Manufacturers. Several builders of storage facilities and manufacturers of prefabricated buildings maintain research laboratories which are used for testing components of buildings as to their suitability for use as grain storage facilities. Some manufacturers perform filed tests on structures and several use a high degree of instrumentation to solve structural load problems and thus improve the quality and safety of the structures. Some builders have found it necessary to employ research engineers and designers to adapt new construction techniques and materials to economical and functional grain storage facilities. Estimated annual expenditures are equivalent to approximately 9 professional man-years.

Industry Organizations. Various industries have organized into general associations for research and promotion. These associations are conducting research on building materials such as "tilt-up" concrete construction for buildings; multishaped, lightweight roofs; and improved weather resistant coatings for steel. Estimated annual expenditures are equivalent to approximately 15 professional man-years.

Trade Associations. State, regional, and national fruit and vegetable and trade associations have a special interest in the problems of packing, handling, storing, and distributing fruits and vegetables. Although most of their efforts are of an informational and promotional nature, some staff members provide a part-time consulting service on operating problems, amounting to an equivalent annual expenditure of 15 man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Design of Grain Storage Structures

Field studies made in 1961 showed that current construction costs of modern upright concrete elevators (200,000- to 500,000-bushel capacity) in the Central Great Plains averaged about $0.70 per bushel. These elevators receive annually a volume of grain equal to 1.1 times their average capacity. Receiving capacities ranged from 5,000 to 8,000 bushels per hour per elevator. In comparison, costs for modern flat storage facilities, common in the grain sorghum producing areas of Texas, averaged about $0.31 per bushel. However, these storages could only receive about 2,500 bushels per hour per storage, and the volume of grain received annually averaged only 70 percent of the storage capacity. Modern elevators in the Corn Belt were similar to those in the Great Plains, except that they receive annually approximately four times their storage capacity.

Tests conducted on large concrete upright commercial grain storages showed that the strength of the concrete used varied considerable with the contractor building the structure. All storages tested were designed on the basis of 3,000 psi (pounds per square inch) concrete. However, the average strength of concrete in storages built by one contractor averaged 4,000 psi while that used by another contractor averaged only 2,800 psi. The strength of the concrete also varied considerably throughout any one structure. For example, the strength of one typical storage varied from 2,300 psi to 3,000 psi at different points on the wall at the same height but at different locations around the perimeter. There was even more variation in the strength of the concrete at different heights. For example, the strength of concrete in the walls of one structure varied with the height from 1,800 psi to 5,400 psi. These tests indicate a need for better quality control in the construction of concrete grain storages.

The queuing theory, an accepted technique of operations research, is being used to develop improved layouts and designs of truck unloading facilities which will reduce waiting time and costs at the elevator during harvest. Field studies were conducted during both the grain sorghum and wheat harvests in Kansas to collect data on truck arrival and service time patterns.

At the elevators studied, about 22 percent of the total number of trucks arriving during the harvest season arrived in one day and about 10 percent of the total trucks arriving in a day arrived during one hour, usually between 4:00 and 5:00 p.m. During any one hour, truck arrivals follow a Poisson distribution--a statistical pattern where arrivals occur at random times but where the expected number of arrivals is approximately proportional to the length of the time intervals--thus, when truck arrivals averaged 36 trucks per hour, 3 trucks would be expected in a 5-minute period. The service time patterns for weighing and unloading trucks follow closely an Erlang distribution--a statistical distribution function often used in the theoretical waiting line analysis.

Handling Grain in Country Elevators and Terminal Storages

At College Station, Tex., work during 1961 was confined to the preparation of a manuscript on "Receiving Grain Sorghum at Country Elevators in the Southwest" which has been published.

At Manhattan, Kans., a report, "Receiving Grain from Trucks at Country Elevators in the Hard Winter Wheat Area," was completed and submitted for publication. The report includes results of studies of observed and improved methods for (1) truck scale operation, (2) unloading trucks, and (3) moving grain from drive pit to headhouse. A good layout of equipment and coordinated methods at the truck scale are important to rapid and efficient weighing of farm trucks during

harvest. Using the methods observed at country elevators, a 3-man crew at the drive pit unloaded trucks at a rate of 5,850 bushels per hour with a direct labor and equipment cost of 18.6 cents a truck. An improved method using a 3-man crew increased the receiving rate to 7,400 bushels per hour while reducing the direct labor and equipment cost to 16.1 cents a truck. Recommendations presented will be useful to elevator managers in selecting improved methods, equipment, and equipment layout for receiving farm trucks at country elevators.

Another report on a "Full Bin Indicator for Grain Elevators" was completed and published. This report discusses an inexpensive, portable indicator for indicating when bins in grain elevators are full. This report has been given wide distribution in grain trade magazines and it is anticipated that this device will be widely used by country elevator operators with a saving in time, cost, and manpower. By sounding a warning when a bin of grain is full, bin overflows can be prevented in which grain piles up at the rate of 100 bushels per minute. Also the time required for measuring a bin during the filling operation can be appreciably reduced.

Field studies of grain shipping operations at country elevators have been completed and a report prepared entitled "Shipping Grain from Country Elevators in the Hard Winter Wheat Area." This report compares labor and equipment costs for shipping grain from elevators of different sizes using 2-man crews. Comparative labor and equipment costs were as follows: 200,000-bushel elevator--0.51 cent per bushel; 750,000-bushel elevator--0.48 cent per bushel; and 1,500,000-bushel elevator--0.46 cent per bushel. The elapsed time to load a box car varied from 52 minutes when using a car puller, a bifurcated spout with hand winch, and a 25-bushel capacity automatic scale, to 83.4 minutes when using a hand operated car mover, a single flexspout with wire stretchers, and a 10-bushel capacity automatic scale.

Field studies of receiving grain by rail car at terminal elevators were initiated in 1961 and completed in 1962. In 1961 time studies of unloading rail cars at terminals were obtained for (1) power shovels with 4-man and 6-man crews; and (2) car dumpers of two different makes. The average time to unload 796 cars with a 4-man crew using power shovels was 15.4 minutes per car at a labor cost of about 6-1/2 cents per bushel. Additional studies during 1962 included unloading cars with a paddle conveyor, an "augermobile" and "Kar-Flo" (shaker), and one make of car dumper. The paddle conveyor and the "augermobile" each left approximately 6 inches of grain in the bottom of the box car which was then removed by use of power shovels. Handling reports from one terminal elevator for a two-month period showed the elapsed time for unloading cars with one make of car dumper was 8 minutes, and for loading a car, 4-1/2 minutes.

Summaries of daily grain handling reports were compiled for two terminal elevators for two years. One terminal, equipped for unloading box cars with power shovels and with elevating legs moving 15,000 bushels per hour, moved an average of 2,059,000 bushels each month. The average electric power cost for one year was 2.29 cents per kilowat hour. Another terminal, equipped for unloading with a car dumper and with legs moving 30,000 bushels per hour, moved an average of 4,657,000 bushels each month. The average electric power cost was 1.85 cents per kilowatt hour. Such information will be particularly useful in evaluating equipment usage and normal handling capacities at terminal elevators.

A comparative test of wear resistance of various liner materials for grain spouts is underway. The quantity of grain handled before the material is worn out is being recorded at an operating grain elevator.

A comprehensive study of grain cooling during turning operations and extended periods of storage has been underway during a two year period. Grain temperatures were recorded during storage, including temperature changes while the grain was turned three times--summer, fall, and winter. The maximum variation in temperature of grain against the outside wall was 7° F. while the outside air temperature varied 23° F. The maximum grain temperature lagged the maximum outside air temperature by about 4 hours in the afternoon and the lag for the minimum temperature in the morning was about 3 hours. There was little or no daily fluctuation in temperature in grain 6 inches in from the sidewalls.

In another test a bin was filled at harvest time with wheat with an average temperature of 92° F. The wheat was turned three times--summer, late fall, and late winter--after which the average grain temperature was 56° F. Average changes during the eight months of storage included: Grain moisture reduced from 11.6 to 11.4 percent, test weight increased from 61.2 pounds per bushel to 62.4 pounds, and germination reduced from 96 percent to 92 percent. The official grade was No. 1 Yellow Hard Winter Wheat throughout the storage period. Following the late winter turn, this lot of wheat was placed in static storage to remain for one year unless grain temperature or other changes indicate a need to turn.

In 1962, observations were made of different methods used for receiving, sampling, and storing wheat at elevators where sedimentation values are used as a premium factor. Most wheat was received and stored at country elevators without regard to quality determinations. Wheat samples obtained from a number of storages had sedimentation values ranging from 24 to 67 (premium range is 40 to 65). Storage treatments planned by different elevator operators include static storage, aeration, turning twice annually, and turning as frequently as once each month.

Storage of Grain in CCC Bins

Studies of maintaining the quality of shelled corn by using standard USDA aeration systems in 3,250-bushel bins are on a continuing year-to-year basis. Corn from the 1955 crop year was stored in September 1956 with an initial moisture content of 14 percent. Continuous aeration over a 6-year period has reduced the moisture content to 12.5 percent. During the same period, total damage increased about 7 percentage points. A continuously-operated fan caused a slight wetting of the surface corn during the winter months but this corn dried during the spring and summer. Since airflow was downward through the corn, the drying action at the surface wetted areas of corn deeper in the bin. Various methods of fan control are being studied to lessen this moisture increase. In one test, fans operated as exhausters until December, stopped until February, then operated until September moved the excess moisture out of or redistributed it in the corn mass. In a variation of this test, fans operated as exhausters until January instead of December.

Samples drawn from the upper eight feet of shelled corn in these test bins show an average increase in total damage of less than one percentage point after two years of storage. Increases in total damage in comparable test bins with the fan operating continuously in the exhaust position were slightly less than two percentage points. Corn stored in the fall of 1961 at a different moisture showed about the same ratio of increases in total damage after one year of storage. There was no significant advantage in operating the fans as exhausters until January instead of December.

Shelled corn stored in two flat storages was aerated at an airflow rate of 1/8 cfm per bushel with the airflow direction reversed in one of the two buildings. This corn was placed in storage in the fall of 1960 with a moisture content of about 14.5 percent. In this study the fans were controlled by a time clock which permitted four hours of fan operation daily between September 1 and June 1 with a different four hour period from September to December, December to March, and from March to June. After 1-1/2 years, data from the above tests indicate that with the fan operating as a blower the corn has more uniform moisture and temperature patterns, less increase in total damage, and a higher germination.

Handling and Storing Cotton Bales

Work has been completed on improved designs for cotton compresses of three types of construction--wood-pole, prefabricated steel, and concrete. Each of these designs includes a compressing compartment and six storage compartments for storing a total of about 45,000 compressed bales of cotton. Current estimated construction costs for

the warehouses and compresses are: Wood-pole, $2.95 per square foot; prefabricated steel, $4.20 per square foot; and concrete, $4.95 per square foot. The estimated annual facility costs (includes depreciation, building insurance, taxes, interest and maintenance) for the warehouses are: Wood-pole--$71,800; prefabricated steel--$84,300; and concrete-$79,900. The insurance cost on the stored cotton is about $2,000 a year less for the all concrete warehouse than for the other two designs.

The compress of concrete construction was selected for further development and more detailed drawings and specifications were prepared for this design. Detailed labor and equipment requirements and costs also were developed. Some of the advantages of this design are: Long span construction using prestressed concrete roof beams to reduce column interference and increase flexibility of storing and handling operations; proper aisle location and bale stacking pattern, thus reducing the size of each compartment to under 30,000 square feet yet providing storage space for 7,500 bales (maximum allowable under insurance regulations); and layout of equipment and machinery in the compress compartment for reduced crew interference and increased efficiency of handling operations.

A final report covering the research on warehouses for storing compressed bales has been completed and published. With the completion of this report this project was discontinued.

A film on Cotton Warehousing, Modern Methods and Equipment, was completed and copies have been placed in five State University libraries. Many warehousemen have viewed the film and adopted some of the handling operations that were shown. It is expected that this film will be of value to warehousemen in helping them to increase productivity and reduce handling costs.

Research and development work covering improved methods, and new and improved equipment, for handling, tagging, and storing flat and compressed bales of cotton is being conducted in California and Arizona.

Layouts for clear span prefabricated steel compartments, 100 by 300 feet and 100 by 400 feet, are being developed to permit the use of newly developed storage patterns for flat and compressed bales and modern improved and new handling equipment.

Swivel pliers for attaching tags to bales with heavy duty, 12-1/2 gauge, triangular rings were developed and tested on flat and compressed bales. Productivity was increased and tag costs reduced. Lost and mutilated tags have been reduced by more than 95 percent according to reports received from 8 warehouses where this type of plier and rings has been used for 8 months. A report entitled "Better and Faster Tagging of Cotton Bales," which illustrates and discusses the use of this equipment, has been prepared and published.

Equipment for weighing bales on the automatic dinky press feeder was developed and tested in 8 warehouses. A-frames were erected over the dinky press feeder platforms and electronic scales suspended from a hoist attached to the top rail of the A-frame. Labor requirements were reduced and productivity maintained using this type of equipment and weighing method, regardless of the speed of compressing. Crew size was reduced from 7 to 3 workers and weighing and checking accuracy was increased by more than 90 percent.

Studies were conducted on improved and new stacking patterns for flat and compressed bales. It was found that flat bales stacked 4-high on-head withstand earth tremors as well as bales stacked 3-high on-head. Warehousemen using this stacking pattern can store the maximum number of bales allowed under present insurance regulations, (7,500) in a warehouse 100 by 300 feet with 21-foot sidewalls and clear span construction. Compressed bales stacked 2-high on-head in rows 2 bales wide can be stored in 67 percent less time by clamp truck than when stacked in 5-high cordwood stacks. Breakout time and expense is reduced around 75 percent as one worker using a Garrett breakout device can do the work of three workers and two machines.

Studies were made on clamp trucks carrying unit loads of 9, 12, 16, 20, or 24 flat or compressed bales. One clamp truck carrying 16 flat bales can transport about 500 bales per hour over a distance of 1,000 feet. This includes picking up the bales, moving them 1,000 feet and setting them down in a temporary block. These trucks with pneumatic tires can travel from 20 to 25 miles per hour with a full load on concrete, asphalt, earth, and semi-packed gravel or sand.

Handling and Storing Rice

In connection with rice research in Texas, a manuscript on "Receiving Rice by Farm Trucks at Commercial Rice Dryers" was prepared and published. No additional work has been done on handling.

The greatest emphasis and progress in the rice drying research since the experimental dryer was completed in 1957 has been in the use of aeration in rice drying operations. Cooling rice with aeration during the tempering period has shown a significant saving of both dryer time and fuel cost over the conventional method of tempering at a high temperature with no aeration. This is due to the drying which occurs during tempering when aeration is used. Research data consistently showed that at least one pass through the dryer could be eliminated by cooling rice with aeration during the tempering period.

In a case study at a commercial dryer, aeration was used during the tempering periods and two passes through the dryer were eliminated. Computed costs of drying showed a saving of over $5,000 per year when aeration was used as compared to tempering rice at high temperatures with no aeration. Aeration was effective in preventing souring of rice tempered at temperatures of 120 to 130° F. Bins of rice with no aeration began souring with tempering periods of only four to six hours. A report on "Drying Rice in Heated Air Dryers with Aeration as a Supplemental Treatment" was prepared and published.

Aeration was also found to be useful for extending the safe storage period of green high-moisture rice before passage through the dryer. Aerated green rice was maintained at near outdoor air temperature and spontaneous heating was avoided. In a series of aeration tests with barrel lots of undried rice, using an airflow rate of 1/2 cfm per barrel, Bluebonnet rice at a moisture content of 23.5 percent was maintained at grade No. 1 for 48 hours; Nato rice at 21 percent was maintained at grade No. 1 for 144 hours; and TP49 rice at 19.5 percent was maintained at grade No. 1 for 22 days. Additional tests are needed to obtain information about the relative importance of ambient temperature, rice variety, and airflow rate as concerned with maintaining the quality of green rice.

Three varieties of rice were received at the experimental rice dryer during the harvest season of 1961. These were divided into lots ranging in size from 324 to 405 hundredweight. The drying procedure was set up to test the effect of drying temperature (of rice leaving the dryer) upon the subsequent yield of head rice. A temperature of 110° F. resulted in a slightly higher yield of head rice than 120° F., and in a much higher yield than rice dried at 130° F. There was no difference in head rice yield between lots dried at 100 and 110° F. Excessive variation in the milling yields caused these results to be statistically insignificant. For instance, the variation in yields of head rice within lots dried at 110° F. was nearly as great as the variation between these and other lots receiving different temperature treatments.

A test was conducted on the use of radiation-resisting paint for coating rice storages. Lower temperatures have been noted in bins covered with this paint as compared with bins receiving no paint treatment. The test is not yet completed so it is not known if the lower temperatures of the stored rice will result in better maintenance of the quality of the rice.

Storage of Deciduous Fruit

Cooling Rates. The purposes of this research are to: (1) Measure and evaluate the cooling rates of fruits in storage and shipping containers in terms of container designs that properly protect the fruit, shorten the cooling period, and maintain the fruit at proper storage temperatures and (2) develop improved handling, stacking, and storage practices.

Cooling rate studies of apples packed in vented fiberboard boxes conducted during the 1959-60 season, in cooperation with the Horticultural Crops Branch, MQRD, AMS, were completed and an article prepared and published. These tests, although quite lengthy, did not establish the optimum means of venting fiberboard boxes. However, they did prove that the present commercial method of venting fiberboard boxes does not markedly increase the cooling rate over nonvented boxes.

A cooling study of apples packed in fiberboard boxes, using full wrap and both perforated and nonperforated trays, was made in a storage under regular commercial conditions. The test showed that there was practically no difference in the cooling rate between the two types of packs, which was to be expected as the paper wraps on a full wrap pack have a tendency to close off any air circulation passages. This is in agreement with earlier tests made in the laboratory.

Spot checks were made of apples in three different storages in various types of containers to determine the core temperature of the stored fruit. In most cases, the core temperature of the fruit checked closer than 1° F. to the room air.

Work was done on the cooling of packed cherries stacked on pallets using the chimney stack method in which the lugs are arranged so as to leave a hole up through the center of the stacks. In one test run the cherries cooled only 5° F. in 18 hours when the average room air was 31° F. Because of this poor cooling rate, the chimney method of stacking was immediately abandoned for a more desirable method.

A cooling study was made of cherries packed in a gift package consisting of a chipboard box containing 5 pounds of Bing cherries. These packages were precooled to 35° F., then mailed to various locations. Because of the longer time anticipated for the gift packages to reach their destination, the cherries were in very poor condition on arrival. Judging from simulated shipments in which the packages were held in the Wenatchee laboratory at room temperature, 4 days would be a permissible shipping period for the type of gift package used in these tests.

A cooling study of pears packed in fiberboard containers and standard wood lugs was conducted in a commerical cold storage plant but the data obtained were of little value because of the handling and movement within the storage of the fruit during test. However, the test does indicate that the cooling rate of pears packed in fiberboard containers is essentially the same as pears packed in standard wood lugs. After ten days storage the fiberboard containers stabilized at a temperature 0.2° F. higher than the standard wood lugs.

A cooling study was conducted of apples packed in fiberboard containers and stacked in two different methods on pallets. The loose stacking method resulted faster cooling of the apples and a lower stabilized temperature.

Refrigerated Storage. The objectives of this project are: (1) To investigate airflow and distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and on bringing it to optimum storage temperatures; (2) to determine and evaluate heat gains through various structural features of fruit storages and make suggestions for improved designs; and (3) redesign storage houses for the most efficient handling and storage of fruit in pallet boxes.

In order to facilitate the movement of pallet boxes and pallet loads of apples into and out of a cold storage house, an air door, or air curtain, was designed, installed, and tested at a commercial apple storage plant in Wenatchee, Washington during 1960-61. This air door gives a clear and unobstructed view through the door opening at all times. The air door effectively sealed the entrance and acted as an insulating curtain. It eliminates the need for swinging or sliding doors. The report entitled "Air Door for Cold Storage Houses" was published.

Periodic checks were made at three storages to measure the difference in air temperatures between the stored fruit in pallet boxes and in fiberboard boxes. The humidity was checked at the same time with a sling psychrometer. These storages were of 25,000-, 55,000-, and 145,000-box (loose fruit) capacity. Cold storages using ammonia cooling systems were able to raise their humidity by increasing the back pressure to the compressors. The relative humidity was raised to 85 percent or better in these storages. Storages using Freon for a refrigerant and having a minimum amount of coil surface could not change their system back pressure to effectively raise the humidity. Buckets of water were splashed in the aisles on the floor each day which improved the relative humidity to a satisfactory level of 80 to 85 percent. The research indicates that humidifiers should be installed in these storages to overcome inadequate coil surface.

During the erection of a steel-type cold storage warehouse near Orondo, Washington, thermocouples were placed in the ground under the concrete floor slab, in the walls, and in the ceiling. Periodic temperature readings have been taken from these thermocouples during the past season. These readings will be used in calculating the insulation value of the various components of the building.

Because of the lack of facilities for conducting needed tests, research to develop a method for improving the cooling rate of fruit by varying the static pressure on the room was discontinued.

One storage which was checked for air distribution temperatures, showed that temperatures in various locations ranged from 29.6° to 33.3° F. The relative humidity was 85 percent.

In a cold storage house at Chelan Falls, Wash., which contained four separate rooms, a complete check was made on the storage temperatures of the apples throughout the storage season. Temperature readings were taken weekly from 43 thermocouples installed at various places in the storage rooms. Some of the thermocouples were placed directly in an apple in the center of the boxes to record the fruit temperature and other thermocouples were placed in the adjacent air. Only selected apples, of the quality that would be placed in a C.A. room, were placed in this storage.

In cooperation with the Horticultural Crops Branch, MQ, apples from the same lot were placed in C.A. rooms at the Wenatchee laboratory for a comparative study.

Apples at the Chelan Falls storage were examined on January 8, February 23, and April 11, for pressures and keeping quality and found in excellent condition. In one room of the storage house, which did not cool properly, the fruit was ripe by the first of February. The other three storage rooms had good temperature control and the fruit was in excellent condition when sold in late March and April. Prices received for this fruit was exceptionally good and, in most cases, equaled that received for C.A. fruit. The relative humidity was maintained at 85 percent. This was accomplished by placing tubs of water in the storage rooms and using burlap as a wicking in the tubs. The water was kept from freezing by adding salt.

This test also showed that thermometers in the center aisles or at the ends of a storage room do not indicate the true temperature of the stored fruit.

The manuscript for the report on "Apple Packing and Storage Houses--Layouts and Designs" was completed and submitted for Department publication.

Controlled Atmosphere Storage of Apples. Work on this project is designed to develop improved methods, techniques, equipment and facilities for the controlled atmosphere (C.A.) storage of apples in the Pacific Northwest.

Current controlled atmosphere storage studied carried on in the laboratory in cooperation with the Horticultural Crops Branch, MQ, were designed to determine the importance of the following factors and procedures in obtaining optimum C.A. storage of apples: (1) Maturity of fruit at harvest; (2) time interval for lowering oxygen content to the 5 percent level, as required by law in the States of New York, Michigan, California, and Washington; (3) period of time apples might be held in 31° F. regular storage before they are placed under C.A. conditions and still benefit from C.A. storage; and (4) various levels of oxygen and carbon dioxide.

In conducting these tests during 1960-61, apples picked at three different maturity dates--140, 150, and 160 days from full bloom--were packed and placed in the two C.A. laboratory test rooms. The oxygen level in each room was reduced to 3 percent. The CO_2 level in one room was maintained at 5 percent and in the second room at less than 1 percent. The CO_2 was removed from the room atmosphere by bubbling the air through a solution of monoethanolamine, which absorbed this CO_2. When the CO_2 level started to rise, the monoethanolamine solution was replaced and the used solution rejuvenated by heating and driving off the absorbed CO_2. The temperature of the rooms was maintained at 30° to 31° F. Apples removed from the C.A. rooms on April 11, 1961 showed a somewhat higher pressure test than the check lot that was held in regular cold storage at 31° F. However, after being at 70° F. for 18 days to test their shelflife, the C.A. fruit generally showed a lower pressure test than the check fruit, the only exception being the 160-day fruit held in the room with less than 1 percent CO_2. The average dessert quality of the fruit judged by a test panel generally showed C.A. held fruit to be better than the check for Delicious apples, however, the panel rated Golden Delicious apples held in regular storage higher than that held in C.A. storage. These tests have not been conclusive and need to be continued.

Experimental equipment was designed, built, and tested for burning the oxygen from the air in a C.A. room. The oxygen level was lowered very rapidly by this method but at the same time the carbon monoxide gas was raised to an undesirable level. The tests were discontinued because of this generation of carbon monoxide gas.

Apples from the same lot of fruit stored in a commercial storage at Chelan Falls, Wash., were stored in the C.A. rooms at the laboratory in Wenatchee. In both cases, this fruit was selected for the best quality and maturity. Results indicated that fruit stored in properly managed regular commercial storages is equal to C.A. stored fruit. Samples from the C.A. rooms tested on January 24, 1962 tested 15.2 pounds. The highest average pressure on C.A. fruit was 15.2 pounds, and on the regular commercial storage fruit - 15.2 pounds.

Storage of Potatoes

Table Stock and Seed. Work under this program is directed toward providing optimum storage conditions for fall-crop potatoes; developing improved layouts and designs for potato storage and packinghouses which will permit the use of the most efficient handling and packing methods and keeping injury and mechanical injury to a minimum; while minimizing construction and maintenance costs.

The manuscript, "Shell Ventilated Systems for Potato Storages in the Fall-Crop Area," was completely rewritten. A first rough draft of a manuscript, "Fall-Crop Potato Storages," which includes recommendations regarding construction techniques, layout and design, air circulation and ventilation system, insulation, and building materials was prepared. A number of general plans are also included which were developed around the most efficient handling system and methods.

Line sketches have been prepared for ten general types of potato storages for fall-crop States. Ventilation and air circulation systems have been included in the designs of these storages. These drawings, when completely detailed, can be used to evaluate the handling facilities, construction costs, and operating costs of the most common types of storages in the fall-crop areas.

During the two-year report period, project personnel provided assistance on problems associated with storage construction and regulation, handling, and equipment to approximately 600 firms and individuals.

Processing. Four 10- x 18- x 10-feet deep, bulk storage bins at the Red River Valley Potato Research Center were converted into 40°, 45°, 50°, and 65° F. storage rooms. This remodeling included installing insulation, vapor barriers and sheathing. A 5-ton capacity heat pump, auxiliary blower, thermostats, and ducts were installed for regulating temperature in the individual rooms. Ceiling tracks, trolleys, and hoists were provided for moving pallet boxes between rooms and for weighing the boxes with a dial scale.

A closed circuit cooling system was installed in the 40° and 45° F. rooms so that all heat exchange between the refrigerated closed air circuit and the control rooms was through carefully vapor-proofed corrugated sheet metal ceilings. However, provisions were also made for direct cooling by circulating cold air in the rooms.

Two 1-ton pallet box lots each of Red Pontiac, Irish Cobbler, Norland, and Snowflake potatoes were stored in each of the 40°, 45°, and 50° F. holding rooms. In October, and bi-weekly thereafter, each one of the 24 1-ton boxes of potatoes were weighed and their specific gravity determined. Starting in February 1962, a 300-pound sample of each variety was removed every 4 weeks from each of the 3 control rooms. Samples from the 40° and 45° F. rooms were held for 4 weeks in the 65° F. conditioning room before being taken to the University of North Dakota pilot plant for processing into potato flakes and dehydrated slices. Samples from the 50° F. room were processed without further conditioning. The rooms were regulated by ventilation and electric heat until late in February when the heat pump was started. Regulation by the heat pump was satisfactory until about May 1; after which the temperatures could not be kept low enough. Sample lots were processed up to and including the first week in August. The UND made a preliminary comparative judgment of the quality of flakes from the lots for each storage period.

An analysis of the shrinkage data will be completed after the 1962 harvest season. Also the processing data from the UND pilot plant should be available by then. Specific gravity determinations showed no consistent change in any of the rooms during a 7-month storage period. Preliminary judgment was that the two lots of potatoes which were taken from the 45° and 50° F. rooms during the fourth week in July and the first week in August processed as well as the earlier lots of potatoes even though the earlier lots seemed firmer.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Grain

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III. MAINTENANCE OF PRODUCT QUALITY DURING TRANSPORTATION AND STORAGE

MAINTENANCE OF MARKET QUALITY
Market Quality Research Div., AMS

Problem. Waste and spoilage of perishable agricultural products as a result of physiological and microbial action occurring during transit and storage results in serious losses. Effective control methods are needed to reduce these losses and prevent quality deterioration.

Reliable information also is needed regarding the effects upon the quality of perishable products of changed environmental conditions resulting from the adoption of new containers, new types of rail, truck, air, and ship equipment, the heavier loads needed to take advantage of incentive rail rates, and faster train schedules.

USDA PROGRAM

The Department has a continuing program of applied and basic research involving horticulturists, plant physiologists, plant pathologists, food technologists, seed technologists, bacteriologists, chemists, engineers, and entomologists. The work is carried on at Beltsville, Maryland; Washington, D. C.; New York City; Chicago, Illinois. Fresno, California; Miami and Orlando, Florida; Athens, Georgia; Watseka, Illinois; Ames, Iowa; Manhattan, Kansas; Presque Isle, Maine; East Grand Forks, Minnesota; College Station and Harlingen, Texas; and Wenatchee, Washington, and in cooperation with the Califronia, Florida, Georgia, Maine, Maryland, Michigan, and North Carolina Agricultural Experiment Stations, the Florida Citrus Commission, Red River Valley Potato Growers Association and other industry groups. The total professional Federal man-years involved in fiscal year 1962 were 31.0 of which 3.5 were devoted to work on grains, 3.0 to poultry products, 23.3 to fruits and vegetables, 0.5 to cut flowers and ornamentals and 0.7 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961, reported work on physical and biological problems which are encountered in storing, handling and transporting agricultural commodities and products involving about 68 man-years. Of this total 14 man-years were devoted to market quality research relating to citrus and subtropical fruits, 16 man-years to deciduous fruits and tree nuts, 8 man-years to livestock and meats, 6 man-years to poultry and 24 man-years to vegetables.

Industry and Other Organizations. Research by chemical companies on products to control decay of citrus fruit amount to an estimated

annual expenditure equivalent to approximately 2 professional man years. Similarly a large cooperative in California does research on disease control, packaging and transportation amounting to about 2 man years, and the Florida Citrus Commission about 1 man year on packaging and decay control.

Chemical companies and dried fruit and wine companies conduct limited research involving market quality of dried fruits. This effort in 1961 was estimated as about 7 professional man-years. Potato processors devote approximately 2 man-years to work on biochemical changes in potatoes during storage as affecting suitability for processing.

Chemical companies, engaged in the formulation of insecticides, also do some research relating to the maintenance of quality during storage and transportation both directly and in cooperation with the Department. Estimated annual expenditures are equivalent to about 5 professional man-years. Professional and trade groups also may contribute about an equal amount of effort.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Citrus and Subtropical Fruits

1. Controlled Atmosphere Storage of Citrus Fruit. Experiments were continued to extend the storage period of Texas red grapefruit by controlling the storage atmosphere. Pretreatment for 4 days at 80°F following harvest was effective in reducing decay and pitting in fruit stored early in January but not in fruit stored in late November. This treatment also reduced decay of fruit held in air.

Decay was of no importance in any of the lots during the first 98 days storage. At the end of 140 days, January-harvested fruit stored at 41°F was 32 percent decayed and November-harvested fruit, 74 percent. However, when stored at 46°, losses of January fruit were only 5 percent and of November fruit, 9 percent.

Washington navel oranges were stored in California up to 4 months in 5 percent oxygen and no carbon dioxide, and in 5 percent oxygen and 5 percent carbon dioxide at 40°F. Flavor and appearance were retained well in the atmosphere containing 5 percent oxygen and no carbon dioxide, but the flavor was impaired in oranges held in the atmosphere containing 5 percent carbon dioxide. Oranges stored in normal air retained flavor quite well, but deteriorated in appearance because of shrinkage and dullness. Decay was much more prevalent in oranges stored in controlled atmospheres than in comparable fruit stored in air.

2. Storage of Pope's Summer Oranges. (Florida) Pope's summer oranges stored 2 and 3 months at 32°F developed much less decay and rind breakdown during the subsequent 7-day holding period at 70° than fruit stored at 38°F. In 1960, oranges picked in April had less decay after storage than fruit picked in May. The use of 1 percent Dowicide-A and ½ percent hexamine with a wax reduced the occurrence of decay during the holding period after removal from 38°F storage. Fruit picked in April 1960 and May 1961, with solids-to-acid ratios of 18.5-to-1 and 17.5-to-1, respectively, maintained their internal quality during the storage and holding period. Storage off-flavors developed in fruit picked in May 1960 with a solids-to-acid ratio of 23.4-to-1 at harvest.

3. Ripening and Storage of Florida Mangos and Avocados. The most satisfactory temperature for mango storage still appears to be 60°F. Skin color becomes bright at this temperature. Fruit slowly softens (2 to 4 weeks) at this temperature and the flavor of the softened fruit is tart. Ripening at 70° to 80° for 1 or 2 additional days then is necessary for the fruit to become sweet and of good quality. Fruit displaying a color break will withstand storage temperatures below 50°F without becoming injured while those with no color break become injured.

A temperature of 55°F still appears to be both a safe storage and ripening temperature for most avocado varieties. Some varieties developed chilling injury at 50°F.

4. Factors Influencing the Storage and Shelf Life of Florida Persian Limes. Limes dipped in polyethylene emulsions were greener and fresher in appearance than controls after 10 days at 70°F. Limes held at 50°F for 1 month in unventilated polyethylene bags retained a fresh green appearance better than those not bagged but had more decay.

5. Prestorage Treatments and Simulated Transit Temperatures for Florida Grapefruit. Studies were conducted to determine the best transit temperature for Florida grapefruit exported at different seasons of the year. Sixty degrees was found to be the best temperature for Marsh Seedless and Ruby Red grapefruit harvested in October and December. Excessive pitting and decay developed on October harvested grapefruit during the 3-week simulated transit period at 40° and 50°F and the subsequent 2-week 70° holding period. October-and December-harvested fruit held at 32° developed considerable brown staining during the 2-week 70°F simulated marketing period which detracted from the market appearance.

In the fruit harvested in March, little differences were noted in the keeping quality of the grapefruit held at 50° and 60°F. Excessive decay and pitting developed on fruit held at 32° and 40°F. Excessive decay developed in May-harvested fruit at all temperatures; however, grapefruit held at 50° and 60°F had the least amount of pitting and decay.

Washed (but not waxed) grapefruit harvested in October and December developed good color during the 2-to 3-week simulated transit period at 60°F. No pitting and little decay developed under these conditions. When this early grapefruit was waxed, a minimum of 36 to 38 hours of degreening was required for good color to develop.

6. Export Shipment of Florida Grapefruit. In an April test shipment of grapefruit to Hamburg, temperature and humidity aboard ship were accurately maintained in refrigerated stowage but fluctuated in ventilated stowage. No commercially significant rind breakdown developed during the voyage or during the 2-week holding period at 60°F.

Marsh Seedless grapefruit stowed in a refrigerated hold at 50°F arrived with about 1 percent decay, while those stowed at 60° arrived with about 4 percent decay. After storage at 60° for 7 days, the 50°-stowed fruit had about 3 percent decay, and the 60°-stowed fruit had about 8 percent decay; after 14 days the former had about 5 percent, the latter about 13 percent.

Marsh Seedless grapefruit stowed in the ventilated hold (average temperature between 50° and 60°) arrived with about 3 percent decay and developed about 6 percent decay after 7 days at 60°F, and about 11 percent decay after 14 days at 60°. Although the Ruby Red grapefruit followed the same decay pattern as the Marsh Seedless, decay was considerably less, probably due to source differences. Green mold was the frequent disorder on arrival, which indicated fruit injury had taken place. Stem end decay predominated during the 2-week holding period at 60°.

7. Truck-Rail Tests (Cooperation with T & F) Four truck-rail piggyback tests from Florida under ventilation service showed a need for improved loading pattern, modification of the front bunker to provide forced air through longitudinal channels in the load, and the development of a method by which air can be directed into the trailer when the rear of the trailer faces forward, as is often the case after loading on a rail car.

Five truck-rail test shipments with mechanically refrigerated units provided good peripheral cooling but heat from the center of the load was removed slowly.

8. Maintaining the Quality of Hawaiian-Grown Papayas During Shipment to Continental United States. Three test shipments by ship and three by plane were conducted during the year. Papayas shipped by air remained salable about 2 days longer than those transported by ship. Precooling extended the salable life 1 day. Hot water treatment reduced decay by about one half compared with the ethylene dibromide treatment.

9. Effects of a High Nitrogen-Low Oxygen Atmosphere on Bananas. Because of the interest in the use of liquid nitrogen for transit refrigeration and the possibility of having a nearly complete nitrogen atmosphere with little or no oxygen in the transit vehicle, studies were initiated at Beltsville to determine the effects of low oxygen on the fruit. Ripening of green bananas held at 60°F in both 99 and 100 percent nitrogen was retarded. After holding in 100 percent nitrogen for 4 days, bananas ripened slowly in normal air to a dull, yellow color but with normal flavor. After 7 or 10 days in 100 percent nitrogen, bananas ripened poorly or not at all, and were off-flavored. Bananas held in 99 percent nitrogen and 1 percent oxygen for periods up to 10 days ripened in a normal manner with no off-flavor after being removed to normal air.

10. Factors Influencing the Accumulation of Biphenyl in Citrus Fruits and its Effectiveness for Decay Control. California lemons harvested at the B-silver or tree ripe stage decayed more in storage, either with or without biphenyl, than lemons harvested when dark or light green and cured 3 weeks prior to experimental storage.

Biphenyl residue in lemons packed with biphenyl treated sheets rarely exceeded 30 p.p.m. after a simulated overseas transit period (4 weeks) plus a distribution period (2 weeks). All fruit had residues well below the German legal tolerance of 70 p.p.m. Biphenyl residue was 50 to 100 percent higher in lemons held in nonvented cartons than in lemons held in vented cartons under similar conditions. Lemons exposed to biphenyl free air for 1 week at 68°F lost about one-half of the biphenyl absorbed during storage in treated cartons. A report on the results with lemons has been prepared.

The sporulation on California-grown navel oranges inoculated with Penicillium digitatum (Green mold organism) was at least twice as much on fruit in vented cartons with biphenyl sheets as on fruit held under comparable conditions in nonvented cartons. Sporulation was greater on Valencia than on Washington navel oranges held under similar environments, but the nonvented carton was also better than the vented carton for Valencias when biphenyl was used. Sporulation on inoculated navel and Valencia oranges held without biphenyl was appreciably more than on similar fruit held with biphenyl.

Oranges absorbed about twice as much biphenyl as lemons held under the same conditions. Oranges lost biphenyl only one-third as fast as lemons when held in open trays in biphenyl free air after storage.

A method for measuring biphenyl vapor in carton atmospheres was developed. The concentration in vented orange cartons after 1 week at 68°F was 2 to 3 micrograms per liter of air and in nonvented cartons 13 to 33 micrograms. Air saturated with biphenyl at this temperature contains about 50 micrograms biphenyl per liter. The sporulation index was inversely related to the biphenyl concentration.

B. Deciduous Fruits and Tree Nuts

1. Apples. In the 1960-61 season Starking Delicious apples picked at 140, 150, and 160-day intervals after bloom, and stored in controlled atmosphere storage, were slightly firmer at time of removal after 6 months and 8 months of storage than similar fruit held in regular storage at the same temperature. This difference disappeared after a few days at 70°.

The 140-day fruit from regular storage (check fruit) had as high quality as that from controlled atmosphere as judged by a taste panel, but the late-maturity fruit (160 days) was rated higher out of CA storage than the check fruit.

A differential in flesh firmness of approximately 2 pounds existed throughout the storage season between the early maturity and late maturity fruit stored in regular storage and in the CA room maintained at 2.5% oxygen and 0.5% carbon dioxide. Fruit from a room which was maintained at 2.5% oxygen and 5.0% carbon dioxide, softened more rapidly than the other lots when removed to 70° room. The 5% level of carbon dioxide was deleterious, to the fruit.

Fruit removed from controlled atmosphere storage on April 10 and placed in regular 31° storage exhibited the same firmness and total acid content in June as fruit held in CA storage until June. This indicated that the influence of CA storage on these properties was greatest during the fore part of the storage season.

As reported in previous years, the principal distinction found between apples from regular storage and CA storage was the higher acid content in the CA fruit. The acid contents of the 3 maturities at harvest were: 0.285, 0.241, and 0.233 percent. Upon termination of the tests in June, the acid percentages for the regular storage fruit were, 0.142, 0.119, and 0.096; for CA storage with 2.5% O_2 and 5% CO_2,

0.217, 0.169, and 0.173; for CA storage with 2.5% O_2 and 0.5% CO_2, 0.185, 0.160, and 0.167, respectively.

In the 1961-62 season Washington State Delicious apples were stored in controlled atmosphere rooms in which the oxygen level was lowered to 5% in 10 days, 20 days, and 40 days. No significant differences were found in quality of the fruits from any of these lots as determined by flesh firmness, soluble solids, pH, total acid, or flavor after a full seasons storage. The data indicate that the State Law requiring that oxygen be lowered to 5% within 20 days to qualify apples for a CA label, may be more stringent than necessary.

Fruit from a room with 2.5% oxygen was only slightly firmer than that from the room with 5% oxygen, but the difference was statistically significant. No consistent differences were found for solids, pH, acidity, or flavor, although results slightly favored the room with 2.5% oxygen.

Mealy breakdown of California Yellow Newtown apples after removal from controlled atmosphere storage has been a serious problem in some years. Research was conducted to relate this disorder to (1) the vigor of the tree, (2) the field temperature of the fruit (as affected by northern or southern exposure on the tree), (3) the temperature in storage, and (4) the composition of the atmosphere in storage.

Apples examined after 9½ months' storage had no mealy breakdown or internal browning. However, fruit stored at 38° F. was firmer and greener than that stored at 40°. Apples stored in 6 percent CO_2 and 3 percent O_2 (6:3) were slightly firmer and greener than those stored in a 3:3 atmosphere. Fruit stored in either of these atmospheres was much superior to that stored in a 6:8 atmosphere. Yellow Newtowns held in the latter atmosphere had about 10 percent scald; those in the 6:3 atmosphere had no scald; and those in the 3:3 chamber had only a slight amount in one lot.

After 2 weeks at room temperature, mealy breakdown affected from 6 to 22 percent of the fruit harvested from young vigorous trees and subsequently stored in modified atmospheres. Fruit harvested from old, less vigorous trees was practically free from mealy breakdown. Fruit from the south side of the young trees had about 1.5 times as much breakdown as that from the north side. Slightly less breakdown occurred at 38° F. than at 40°.

Respiration rates taken at 53° F. after the storage period showed that of the apples previously held in the 3 different atmospheres, those in the 6:8 atmosphere respired fastest and those in the 6:3 atmosphere respired slowest.

In three truck hauls from orchard to New York City (80 to 100 miles) apples in cell-packed cartons sustained the least bruising. Following in order of increasing damage were fruit in shrink-film overwrapped trays, polyethylene bags, tray layer packs, and jumble-filled packs.

The retail store condition of test lots of McIntosh apples in cell packs, poly bags, and shrink-film overwrapped trays was studied in early 1962. In New York supermarkets, fruit in overwrapped trays had less bruising and puncturing than cell-packed fruit sold in bulk, while poly-bagged fruit had the most bruising and puncturing. After a holding period the amount of fruit decay was greatest in poly bags and least in overwrapped trays. Experimental work has been completed and a manuscript prepared.

Mealy breakdown, one of the most serious disorders of California Yellow Newtown apples held in CA storage, had previously been found to occur in all lots stored at 40° F. in atmospheres of 0 to 10 percent carbon dioxide in combination with 3 percent oxygen. Fruit that was most mature at harvest appeared to be most susceptible to mealy breakdown.

Fruit was harvested on three different dates in the 1960-61 season (Sept. 28, Oct. 6, and Oct. 19) and was stored at 40° F. in atmospheres of 7 or 10 percent carbon dioxide in combination with 3-4 percent oxygen. When removed from storage in mid-June apples from all lots were crisp and juicy. There was slight carbon dioxide injury in fruit held at 10 percent carbon dioxide. When the fruit was held for 1 week at 70° after removal from storage, 71 percent of the fruit from one orchard and 50 percent from another developed mealy breakdown. The disorder could not be correlated with harvest maturity or carbon dioxide level during storage.

To test the accuracy of the RSAVΔ formula, developed previously for film permeability and respiration equilibrium, 135 bushels of apples were stored at 30-32° F. in polyethylene, polypropylene, rubber hydrochloride, and polyvinyl chloride liners. Results of these tests indicate the respiration rate of the apples were within the ranges predicted in the tables developed from the formula. The permeable surfaces of apple liners were not significantly affected by tying the liner tops, and no correction factor is indicated for this closure. Apple temperatures within liners averaged 0.35° F. higher than in boxes without liners. The shipping container caused no significant difference in either the respiration or firmness of apples stored within liners. Firmness readings after 9½ months' storage in sealed liners indicated the performance of all liners used was satisfactory.

Pallet covers and bulk-box covers made of 2-mil polyethylene were beneficial in retarding moisture loss from Golden Delicious apples but were less effective than individual box liners. With the covers, moisture was still lost to the boxes or through the exposed bottom. In one test with fruit stored 5 months at 32° F. in field boxes, weight losses averaged 5.4% in boxes without liners, 3.4% in boxes stored under a pallet cover, and 1.6% in boxes with polyethylene liners. Visible fruit shriveling was extensive only in boxes without liners. Gas concentrations under the pallet covers and bulk-box covers ranged from 0.4 to 1.1% CO_2 and 19.4 to 20.7% O_2. Deterioration in the form of splitting followed by decay under the pallet covers was excessive only when fruit was too ripe for late storage. It was worse in top-layer apples in contact with condensation on the film.

Packets of hydrated lime inserted in cartons effectively absorbed excess CO_2 in 6 tests with Delicious, Golden Delicious, Stayman, and McIntosh apples. With no lime in the sealed liners, CO_2 averaged 5-8% during storage. With $\frac{1}{2}$ pound of lime in a waxed paper or kraft paper bag, CO_2 was held near 1% for 2-3 months at 32°, and then climbed rapidly as the lime was neutralized. With 1 pound of lime, CO_2 was effectively absorbed within the liners and averaged less than 1% during 5 or 6 months' storage. Intermediate levels of 2-4% CO_2 were maintained during storage by inclosing cellophane or perforated polyethylene bags instead of paper bags to hold the lime. These restricted the contact of lime with the air more than kraft or waxed paper bags.

The use of lime in film-lined boxes of Red Delicious was beneficial, as the fruit was firmer after storage than that without lime and less scald developed.

Golden Delicious apples were dipped in solutions (1000 and 2000 ppm) of C_{16} alcohol (cetyl) and C_{20} alcohol and then stored 5 months at 32° F. At the higher concentration the material reduced weight loss during storage about 20% as compared with untreated apples. However, polyethylene liners provided much greater protection from weight loss and shriveling than did the alcohol coatings.

A test to compare the keeping quality of freshly harvested apples stored at 32° or 40° F. for 1 to 5 months in 4 pound perforated polyethylene bags (12 bags to master carton) or in bulk bushel boxes was initiated in the fall of 1961. Red Delicious and Jonathan apples from three orchards were used for the study. On removal from storage at monthly intervals apples were examined and placed on simulated retail display of either 7 days in a refrigerated case or 7 days at 70° F.

The data are not completely analyzed, but it appears that prepackaged apples stored as well if not better than bulk apples, mainly due to less weight loss, shriveling, and decay in the packaged apples. Apples in good condition probably can be safely prepackaged in film bags several months ahead of the time of sale if held in refrigerated storage. Both packaged and bulk apples shriveled more in the refrigerated case than at 70°.

A light transmittance instrument developed for evaluating maturity of apples on the basis of chlorophyll content was given an experimental trial during 1960 in a cooperating grower's packing shed. Several thousand apples of three sizes (Red Delicious and Golden Delicious varieties) were classified into three categories of apparent maturity on the basis of the readings of the instrument. External color difference between these categories were observable with Golden Delicious fruit, but not with Red Delicious.

This fruit then was stored and subjected to several quality determinations at intervals through the storage season, which was about 5 months for Golden Delicious and 8 months for Red Delicious. The laboratory taste panel consistently rated the fruit classed as most "mature" (low chlorophyll) by the instrument as being sweetest. The soluble solids content of this category of fruit was highest also.

The panel rated the Golden Delicious fruit classified as least "mature" (high chlorophyll) by the instrument as being the most acid, but observed no significant difference in acidity among maturity categories of Red Delicious. However, the data on titratable acidity showed no consistent relationship in either variety with maturity category as measured by the instrument. At time of harvest, firmness of all three categories was the same in each variety.

Two large scale taste panel evaluations of preference were made on Red Delicious after $7\frac{1}{2}$ months of storage. The first, made on fruit immediately out of storage indicated that the apples of the least mature category were least preferred. The second evaluation made on fruit held 3 days at room temperature showed no significant differences among the three categories.

After 8 months' storage, Red Delicious classified by the instrument as most mature had most break-down upon holding at room temperature.

The more mature Red Delicious had more water-core than the less mature categories. This is particularly significant since the light transmittance instrument provides a method for detecting this internal defect without cutting the fruit.

In 1961 weekly pickings of Red Delicious and Golden Delicious from young and old trees were separated by light transmittance readings into high, medium, and low chlorophyll, and stored at 32°F. After six months' storage, Golden Delicious fruit of high chlorophyll content at mid-season harvest had only 1-2% rot as compared to 30% rot for low chlorophyll fruit harvested the same date.

After six months' storage, early-harvested, high-chlorophyll-content, Red Delicious apples had developed about 1% decay. Low-chlorophyll fruit harvested a few weeks later developed about 8% decay in the same period. After one week at room temperature, rots increased to about 4% and about 26%, respectively. Scald development in Red Delicious was most serious in the high chlorophyll fruit.

A good correlation between light transmittance readings on the difference meter, specific gravity of the individual apples, and the severity of water core, as shown by examination of the cut fruit, was obtained with Starking Delicious and Winesap apples at time of harvest. Difference Meter readings on Starkings made at intervals during storage were consistently higher than at harvest and not reliable as an indication of water core, particularly as browning or discoloration of the flesh developed.

Initial readings of 60 or higher on size 88-125 Starking indicated apples free of water core. Progressively lower readings indicated increased severity of water core. In February, there was considerable browning of the flesh of the apples with initial difference meter readings indicating moderate water core. Most of the fruit with less initial water core had cleared up by February but examination of this fruit in March disclosed 50% breakdown. By May, even the Starkings which had started the storage season with the slightest water core had developed 20% breakdown.

Difference meter readings on Winesaps during storage were more indicative of the intensity of water core. Most of the water core in this variety cleared up without extensive flesh browning. The discoloration that did occur was confined in most cases to the core area.

A "Mechanical Thumb" for determining firmness of apples, which is not destructive to the fruit, was developed at Wenatchee as an attachment to the Magness-Taylor Pressure Tester. The apple tissue involved is about the same area and volume as that bruised by an inspector when he uses his thumb to test firmness so the fruit need not be discarded after testing.

2. Pears. Polyethylene liners are commonly used in L/A lugs for large-size Bartlett pears marketed in the West. Previous work indicated that storage disorders were affected by the degree of ventilation in the liners, and by the maturity of the fruit at harvest. In current studies, fruit was harvested on three dates (Aug. 10, Aug. 17, and Sept. 1) and stored without liners, in sealed liners, or in liners perforated with five pin holes. Fruit from each harvest was stored at 31° F. until December 5 or January 30.

At the first withdrawal from storage (December 5) all fruit from the first 2 pickings ripened with excellent quality and no core browning. Fruit of the third picking developed much more core browning in either sealed or ventilated liners than without liners.

Fruit withdrawn for ripening on January 30 showed a similar trend, but only the first picking ripened without any core browning. The disorder was most severe in the last picking and worse in liners than in containers without film liners.

Bosc pears harvested on September 13 were packed in sealed or multi-perforated polyethylene liners or without liners and stored for 3 or 5 months.

Carbon dioxide and oxygen levels after 3 months' storage were 3.4:16.7 in the sealed liners and 1.3:20.3 in the perforated ones. The atmospheres were about the same after 5 months' storage.

The fruit ripened without internal breakdown after both storage periods. Quality, however, was relatively poor in all lots, the fruit being mealy and lacking juice. The poor quality was not a result of storage conditions, however, since fruit ripened immediately after harvest was also poor.

In cooperation with the California Tree Fruit Agreement shipping tests were conducted during the 1961 and 1962 seasons to determine suitable transit protective services for the initiation of ripening in Bartlett pears during transit to eastern markets.

Modified icing of standard refrigeration cars provided the moderate temperatures needed for initiation of ripening, but the amount of ice required depended on the flesh firmness and temperature of the fruit. Fruit of 19 pounds pressure test or higher, and 75° F. or lower in temperature, required only an ice replenish at the first icing station and one reicing at Chicago. If initial temperatures were warmer (75° to 85°) two reicings were needed (Council Bluffs, Iowa and Marion, Ohio) and if above 85° the two reicings were needed

earlier during the transit period (Ogden, Utah and Chicago, Illinois). All of these are half-stage services. If the fruit was below 19 pounds at harvest, either full-bunker icing or more reicings at half-stage was needed. If the fruit was mature enough to require pre-cooling, then one reicing was enough (full bunker). This would cost $80.49 less per car than standard refrigeration.

In test shipments of early-season California Bartlett pears to eastern markets in thermostatically controlled rail cars average transit temperatures near 60° F. were suitable for fruit with initial firmness near 20 lbs. and with loading temperatures below 75°. Average temperatures near 55° were desirable for fruit with initial firmness near 18 to 19 lbs. and with moderate loading temperatures.

Modified, half-stage icing of standard cars was used as a comparison with Ice Tempco and mechanical cars, which have thermostatic control. Shipping pears in a pre-iced car, which was replenished at the first reicing station, and was re-iced twiced in transit (Council Bluffs, Iowa and Marion, Ohio) provided average temperatures near 55° F. The pears required about 3 to 4 days' time to ripen after arrival in New York.

Ice Tempco cars equipped with a ceiling duct were found to provide relatively uniform temperatures through the load. Temperatures in cars without a ceiling duct were not uniform. Some mechanically refrigerated cars also had fairly large temperature differences between one end of the load and the other.

3. Peaches. The concentration of Dowicide A was reduced from 0.09% to 0.06% during 1½ hours of hydrocooling in a pilot scale ice-refrigerated, flood-type hydrocooler. The pH of the solution also changed from pH 11.6 to 10.7 When solutions containing 0.1% Dowicide A and adjusted to pH 11.5 were frozen and the ice thus obtained was used to to hydrocool peaches for 1½ hours the concentration of Dowicide A remained almost constant and pH was reduced only to 11.2.

Reduction of Monilinia (brown rot) or Rhizopus decay by this chemical was erratic. Earlier experiments showed that concentrations of 0.05% and lower of Dowicide A were relatively ineffective in reducing post-harvest peach decays. Maintaining the concentration of this chemical in hydrocooling solutions at approximately 0.1% through the use of ice containing the chemical gave effective decay control when the fruit was inoculated shortly before treatment. Erratic decay reduction of peaches with natural infection was considered to be due to the failure of the chemical to reach incipient infections.

The chemical 2,6, dichloro-4-nitroaniline was extremely effective in reducing both Monilinia and Rhizopus decay either when the fruit was freshly inoculated or when inoculated 24 hours before treatment. It had a static effect on Monilinia infections limiting the infections to small spots. It almost completely prevented Rhizopus infection.

During the 1961 season hot water treatments were shown to adversely affect organisms on the surface of the fruit and even after penetration below the skin. Rhizopus and Monilinia decays of peaches were almost completely absent after 2 days holding at 70° F. when freshly inoculated fruit was submerged for 7 minutes in 120° water, 3 minutes in 130° water or 2 minutes in 140° water prior to placing at 70°. A high percentage of the fruit was still sound after 8 days at 70° whereas the check fruit, (dipped in room temperature water) was almost completely decayed after 4 days at 70°. When hot water treatments were applied 24 hours after inoculation they were equally as effective in reducing decays as with freshly inoculated peaches. Temperatures just under the skin after hot water treatment ranged between 105 and 115°. Pit temperatures usually were 5 to 10° higher than the original temperature of the fruit. Treated fruit with 95° pit temperatures was cooled in a flood-type hydrocooler to below 50° in 20 to 25 minutes. Hot air treatments in which the temperature just under the skin reached approximately 105° were not as affective in reducing decay as hot water treatments.

Continued research with hot water dips in 1962 showed them to be effective in reducing both Monilinia and Rhizopus decay of peaches during subsequent holding at 70° F. Dips for 1½ minutes in 130°, or 3½ minutes in 120° water reduced Monilinia decay as effectively as 3 and 7 minute dips respectively, but were slightly less effective in reducing Rhizopus decay. Limited data show that when peaches are transferred to 50° F. immediately after heating in 120° or 130° water or hydrocooled and held at 50° after heat treatment, Monilinia decay is reduced as effectively as when peaches are placed at 70° immediately after heating. Rhizopus decay however, was higher when peaches were hydrocooled. Much of the Rhizopus decay is believed to be due to contamination from the container. Injury sometimes occurred when peaches were hydrocooled after heating. Injury was not evident when peaches were hydrocooled to about 65° rather than 50°.

Hot air (130° F.) reduced both Monilinia and Rhizopus decay of peaches, about as effectively as hot water, but required longer exposure. Air with 80, 90, or 95 percent relative humidity was somewhat more effective in reducing decay than air at 35, 50, or 60 percent relative humidity. At the higher relative humidities in 130° air peaches heated more rapidly and to higher temperatures than in 130° air at the lower relative humidities.

When peaches partially decayed by Monilinia or Rhizopus were heated in hot water the organisms near or on the surface were killed or severely weakened. Spores from the surface of treated peaches did not germinate when streaked on agar plates, and no growth occurred from isolations made about $\frac{1}{4}$ inch under the peach skin. Growth did occur, however, from about 80 percent of the isolations made from decayed flesh near the peach pit.

Rhizopus spores on swab sticks were killed more rapidly at 120° or 140° F. when the relative humidity during exposure was 80 or 90 percent than when the relative humidity was 50 or 70 percent.

Hydrocooling and warming rates of peaches in 3 common shipping containers: baskets, wirebound crates, and corrugated cartons were studied. With hydrocooling water maintained at approximately 35° F., peaches in 3/4-bushel baskets, wirebound crates and corrugated cartons cooled from about 68° to 44° in 20 minutes. At the end of the hydrocooling period, peaches in the center of baskets and cartons were 3 to 7 degrees warmer than peaches in the top or bottom. The slowest rate of cooling in wirebound crates was in bottom layer fruit.

Peaches cooled to 54° F. by hydrocooling in containers before being placed at 70°, warmed to a constant temperature in about 18 hours. The rate of warming following hydrocooling was slowest in corrugated cartons and fastest in wirebound crates.

Cartons formed of corrugated board with flutes running at right angles to the flow of water in the hydrocooler retained only one-half the weight of water that was retained by cartons with flutes parallel to the flow of water.

An average of 24 percent of hydrocooled peaches in 3/4-bushel baskets were bruised as compared to 18 percent in boxes of similar capacity when stacked 5-high during simulated transportation to market. Bruising was rather evenly distributed from top to bottom in the stacks of baskets. Within the stack of corrugated boxes, little difference in incidence of bruising was noted in the top four boxes and each box contained less bruised fruit than a basket correspondingly placed in a stack. However, the number of bruised peaches was high in the bottom box of the carton stack, averaging 29 percent bruised fruits as compared to an average 15 percent in the top four boxes.

Bruises on peaches in baskets were more severe than those in boxes. Of all bruises, 35 percent of those found in baskets were greater than $\frac{1}{2}$-inch in diameter as compared to 26 percent in boxes.

4. Plums. During the 1961 season Santa Rosa plums from two locations in the San Joaquin Valley were stored at 30°, 32°, 36°, or 41° F. for 2, 4, or 6 weeks. The plums were divided into two groups based on appearance. Plums of one group had large, prominent lenticels, which gave them an almost russeted appearance, and those in the other group had small, inconspicuous lenticels, were smooth and uniformly colored. The "russeted" fruit was 2-3 percent higher in soluble solids and superior to the smooth plums in flavor. Keeping quality was not affected by type.

A breakdown associated with overripeness which appeared after 6 weeks' storage was most severe at the two highest temperatures. In a parallel experiment, in which plums were divided into three maturity classes based on color, the only breakdown was in the more mature fruit held at 36° and 41° F.

Three new plum varieties were picked at weekly intervals and the soluble solids content and firmness determined throughout a storage and ripening period. The Nubiana and Laroda varieties, stored for 6 weeks at 32° F., ripened after removal from storage, to good dessert quality if the initial soluble solids content was between 16 and 18 percent. Soluble solids content remained constant during storage. Sound Nubiana plums picked as late as August 16, 3 weeks after the commercial picking date, were still firm enough on October 1 to require 5 to 7 days at 65° F. to ripen. Queen Anne plums had a lower soluble solids content and did not store as well as the other two varieties.

During the 1962 season commercially harvested Nubiana plums were held at 60° F. to determine if they were capable of normal ripening. Two lots averaging less than 15 percent soluble solids did not ripen with satisfactory quality. One lot averaging slightly above 15 percent soluble solids ripened to fair quality.

When Nubiana plums were stored for 7 weeks at 34° F. in sealed polyethylene lug liners, the resulting modified atmospheres (CO_2 7%, O_2 11%) reduced decay, prevented ripening in storage, and delayed ripening during subsequent holding at 70°. This modified atmosphere did not produce off flavors, odors, or other harmful effects.

5. Grapes. Emperor grapes were hydrocooled in the packed lug boxes and fumigated with 1.0 or 0.5 percent SO_2 for 20 minutes prior to storage. The half-cooling time was less than 2 minutes. Wet grapes and containers absorbed about twice as much SO_2 as dry grapes and containers. After 3 months' storage, the hydrocooled fruit had less weight loss and slightly less decay than fruit that was cooled in air. Both the stems and berries of the hydrocooled fruit had a better appearance than fruit in check lots, as evidenced by brighter color and less dessication.

When precooled grapes were fumigated in an Ice Tempco refrigerator car equipped with a ceiling duct, all the fans had to be turned on during the fumigation to obtain reasonably uniform SO_2 concentrations in the load. Following this procedure, maximum concentrations in the space above the load, and in boxes in the "A" and "B" ends of the car were 0.6, 0.3, and 0.4 percent, respectively. When only the by-pass fans were operating, comparable SO_2 concentrations were 1.2, 0.03, and 0.8 percent. The doors or hatches had to be opened to remove the SO_2 from the car in a reasonable time.

The distribution of sulfur dioxide during the fumigation of grapes in railway refrigerator cars and cold storage rooms was studied in an effort to improve decay control and reduce injury to the fruit.

Although uniform gas distribution had been obtained previously in the two-bunker Carotemp experimental car, poor distribution of gas was obtained in the new single-bunker "Ice Tempco" cars. Using the by-pass fan during the fumigation, the maximum concentration of gas in a lug box of grapes in the middle layer, quarterlength position, in the end of the car opposite the bunker was 0.2 percent, compared to 0.8 percent in a comparable position in the end next to the bunker. The maximum concentration in the space above the load was 1.2 percent. In a car loaded with grapes in a different container, the TKV lug, the maximum concentrations of SO_2 in the two respective positions were 0.07 and 0.37 percent. Use of all the car fans after the fumigation did not exhaust the gas satisfactorily.

A common commercial practice is to fumigate grapes in conventional refrigerator cars without fans to distribute the gas. The gas is usually left in the cars until they are "pulled" from the shed. Gas concentrations under these conditions were found to be very uneven and 0.1 percent SO_2 was detected 3 hours after the start of the fumigation. The grapes in the top layer of this load were injured.

A cold storage room fumigated with a calculated 0.25 percent concentration of SO_2 had the calculated concentration of gas in the space above the stacked fruit, but only 0.17 percent gas in the channels between boxes on a pallet, and no measureable amount in the center of the box. The type of grape containers, the tightness of the pack, and the type of lid affected the concentration of gas within the box.

Grapes inoculated with Botrytis spores were treated with sulfur dioxide after various incubation times. Within 6 hours after inoculation and incubation at 68° F. and saturated RH, exposure to 100 p.p.m. sulfur dioxide at 95 percent RH for 12 minutes effectively

controlled decay. Fumigation with the same dose at 58 percent RH did not reduce decay. After a 20-hour incubation period exposure of the grapes to 2,000 p.p.m. for 30 minutes reduced the decay from 96 percent to 53 percent.

Alternaria spores were found to be more resistant to sulfur dioxide than Botrytis spores, but like Botrytis, the sulfur dioxide was much more toxic in the presence of water. The germination of wet Alternaria spores was completely inhibited by exposure to 400 p.p.m. sulfur dioxide for 2 minutes or 100 p.p.m. for 20 minutes. Fumigation with 1,000 p.p.m. at 90 percent RH for 12 minutes and with 4,000 p.p.m. at 80 percent RH for 10 minutes was required for complete inhibition of germination.

6. Dried fruits. In cooperation with the Dried Fruit Association of California a survey was conducted in 1960-61 to compare the quality of dried fruit in retail stores with the initial quality at time of packing. Temperatures and relative humidities were taken in retail stores and the length of time dried fruits remained in marketing channels was determined. A total of 678 packages of dried fruit was carefully examined. Seven percent of the apricot samples, 11 percent of the prune samples, 13 percent of the raisin samples, and 17 percent of the fig samples collected in retail stores were of poor quality because of excessive darkening, insect infestation or other defects. Aging was the primary cause of deterioration, but inadequate packaging and high store temperatures also contributed to excessive deterioration.

7. Strawberries. Preliminary tests to compare refrigerated express and freight service from California to Chicago for strawberries indicated that express shipments were slightly superior but that freight service was feasible. Further shipments are required to properly evaluate the two methods of shipping.

8. Strawberry plants. A storage test using ½ million Catskill strawberry plants was conducted in a commercial storage at Salisbury, Maryland in 1962. The objective was to evaluate the cooling rate of 3 types of packages and 3 stacking patterns. The storage was at 30 ± 1° F. with forced air circulation for a period of one month. Cooling was substantially slower in solid stacks of containers than in spaced double or single stacks, as would be expected. Plants packed in fiberboard cartons cooled slower than those in standard wirebound crates.

9. Cranberries. Film liners and CA storage -- CA storage tests were continued for a second year. In this year's study the relative humidity of the CA chambers was regulated as well as the CO_2 and O_2 levels. None of the controlled atmospheres offered commercial possibilities for increasing storage life beyond that attainable in normal atmosphere. Fruit stored in sealed polyethylene liners decayed more rapidly than that in any other treatment. None of the CA treatments damaged the flavor of cooked fruit.

The effectiveness of a series of hot water and fungicide dip treatments on reducing spoilage of cranberries were evaluated. Water temperatures of 125°, 120° and 70° F. were tested. The fungicides tested were the sodium salt of dehydroacetic acid and Botran (dichloronitroaniline). A delayed treatment and the effect of fluctuating storage temperatures were also studied. Examinations after 3 and 5 months in storage at 38° showed that none of the treatments reduced spoilage below that on control lots.

A supplemental test was included in which half of a lot of healthy berries were inoculated with cranberry pathogens and half were not. Samples of these were treated by dipping in water at 50° (controls) or 125° F. After a holding period at 38° isolations were made from spoiled berries from each lot. Growth of cranberry pathogens occurred in 75% of the isolates made from the controls and in only 6% of those from the 125° dips. The hot water treatment apparently reduced spoilage due to microorganisms but not that due to physiological breakdown.

10. Blueberries. Forced air cooling of packaged blueberries showed that in commercial pallet load quantities (78 to 156 crates of 12 pints each) half cooling times of about 1 hour or less were possible with air movement of about 4 c.f.m. per pint or about 2 hours with air movement of about 1 c.f.m. per pint. Forced air cooling was four or more times faster than that currently obtained by conventional methods of room cooling.

Increasing the amount of nitrogen fertilizer applied during crop development decreased fruit acidity, soluble solids, dry weight and keeping quality and increased total yield slightly. Fruit with less than 0.6% acid or a pH higher than 3.25 at harvest did not keep as well as fruit with more than 0.6% acid or pH values below 3.25.

11. Simulated transit in nitrogen atmospheres. Peaches developed a fermented flavor when held in 100% nitrogen at 60° F. for 4 days or longer, but remained normal in flavor when held in 99% nitrogen at the same temperature with 1% oxygen for periods up to 10 days. Little softening occurred in fruits held in 100 percent nitrogen as compared to that occuring in fruits in 99 percent nitrogen or in normal air. Development of Rhizopus and brown rot of peaches was prevented in 100 percent nitrogen and retarded in 99 percent nitrogen.

The growth of mold was prevented on strawberries held at 33° F. in 100% nitrogen, but not in 99% nitrogen with 1% oxygen or in normal air. Berries held in 100% nitrogen softened more rapidly than in the other atmospheres. Strawberries held in 99 or 100% nitrogen kept as well after removal to normal air as fruit held continuously in normal air. Flavor of strawberries was not affected by holding the berries in 100% nitrogen at 33° for periods up to 10 days.

Growth of Penicillium digitatum, Botrytis cinerea, and Sclerotinia sclerotiorum in vitro was inhibited in 100 percent nitrogen but not in 99 percent. Growth of Phomopsis spp. was retarded in 100 percent nitrogen.

C. Cereals and Seeds

1. Corn. Studies of storage behavior of corn dried to 0, 4, and 8% moisture and in atmospheres of 0, 5, and 20% oxygen at 3 storage temperatures of 1°, 20°, and 50° C. indicate that drying to low moisture levels is feasible but costs and damage inflicted below 2% moisture limits practicality of such low moisture drying. Moisture contents of 2 to 4% appeared to be feasible and resulted in extended storage life with little loss in vigor and viability in these storage studies of two years duration.

Construction of facilities during fiscal year 1962 made possible initiation of studies of microbiological deterioration of corn in storage during the current year at Watseka, Illinois. Examination of some 200 samples from two bins of 1960 crop year blended corn indicated wide variation among the samples in (a) fungus population, (b) germinability, and (c) moisture content.

In a study of corn in two quonset buildings, data indicate that an exhaust system of aeration was not as effective in maintaining quality as was a forced air system. In March 1962, average germination of corn was 63% when aerated by the forced air system vs. 26% when aerated by the fan exhaust system. Striking differences in populations of Aspergillus and Penicillium were evident. A study of grain storage in plastic bags indicated that this storage was unsatisfactory due to failure of the plastic used.

2. Wheat. Under contract with Doty Laboratories, quality tests were performed on stored wheat. Samples of Northern Spring wheat (Selkirk) and Hard Red Winter wheat (Comanche) obtained from the 1960 harvest were placed in storage at 75° F. and at moisture contents of 16, 14, and 12%. Samples were removed and examined for Federal grade, sedimentation, germination, fat acidity, protein content, and moisture, plus analyses conducted on flour from each sample (protein, ash, moisture, maltose, Farinograph, Extensograph, and baking tests). After nine months' storage, the Spring wheat at 16% moisture had declined in germination and sedimentation with corresponding increases in fat acidity values and a decline in baking scores. Fourteen percent moisture samples showed a similar but slower change. Twelve percent moisture samples retained their quality. The Hard Red Winter wheat samples followed essentially the same pattern but at a slower rate.

3. Rice

Mold development in rough rice, Bluebonnet 50, was studied in small bins aerated at air-flow rates of 0.2 to 9.5 cfm per barrel. Virtually 100% of the rice had been invaded by field molds prior to initiation of this study. Storage molds increased and field molds decreased during the storage period. The Aspergillus flavus-oryzae group was predominate. At the minimum aeration rate of 0.2 cfm per barrel, the storage mold prevalence increased to 88% in 16 days, while bins at the highest rate of aeration showed maxima of about 17% in 19 days.

Relation between endosperm discoloration ("damaged" and "heat damaged" kernels) and fungi infesting rough rice was studied. Filtrates from all fungi tested to date stained milled rice, but varied in the degree and type of discoloration caused. Inoculation of sterile rough rice with selected fungus isolates resulted in significant increase in discolored kernels if incubated in a humid atmosphere.

Loss of dry weight of stored rough rice and reduction of milling yields were demonstrated to occur as a result of fungus infestation. For example, after 7 days' storage in a saturated atmosphere, samples inoculated with Penicillium puberulum lost 9.6% dry weight and head rice yield was reduced 18.2%.

4. Seeds. A contract study at Iowa State University in which Kentucky bluegrass, creeping red fescue, cabbage, and onion seed were stored in several packaging materials at five temperature-relative humidity combinations has been completed. Moisture content was found to be the most important factor affecting viability. Seeds were stored successfully for 2 years at room temperature, if their moisture content was at or below 7%. Metal cans were the only completely satisfactory container for maintaining seed viability. The

effect of temperature on viability was intimately related to moisture content. An intensive literature survey of storage is under way. Data are being arranged by a card file system and a series of charts are being developed to summarize existing storage information.

With the availability of new seed laboratory facilities, work on microbiological deterioration of grass seeds has begun. A literature survey has been completed.

5. Flaxseed Storage. Under a P.L. 480 grant a study has been initiated of the influence of storage changes in flaxseed on quality of seed and properties of linseed oil. During the first 2 years from 11 to 15 varieties of oil- and fiber-types of flax were studied. Chemical data were obtained on flaxseed grown in various areas; qualitative and quantitative changes during ripening; technological value as related to climate; influence of storage conditions on quality; and effect of temperature and humidity on quality. Preliminary results revealed lipolytic activity of lipases with optimum activity of pH 5 and 8.0 at 37° C. which indicate the presence of two kinds of enzymes. These data and results obtained in subsequent years will be statistically analyzed.

6. Soybean Oil Storage. Observations at the end of the 3-year period indicate different rates of change in characteristics of soybean oil in storage than in cottonseed oils. Although the once refined soybean oils decrease in color with a linear relationship to time and temperature, the rate of decrease is not dependent on the initial color as was the case of the refined cottonseed oils. Whereas crude cottonseed oils all increased in refined color during the entire storage period (except in the instance of the filtration extracted oil), all of the crude soybean oils decreased in refined color during the first 2 years, but at the end of 3 years there is little further decrease. The crude degummed soybean oils are also following this trend. All of the soybean oils are showing insignificant changes in bleached color and free fatty acids.

The peroxide values of the once refined soybean oils increase at about the same rate as the refined cottonseed oils. The relationship with time-temperature is also linear. Crude soybean oils showed some increase in peroxide value initially and at the end of 3 years showed rapid increase in contrast with crude cottonseed oils which changed little in peroxide value over the entire storage period. The degummed crude soybean oils are following a trend more closely to that of the refined oils.

The data on "dimer" changes and panel evaluations of flavor of soybean oils at the end of 2 years of storage do not definitely indicate any trends or relationships to peroxide value increases during storage.

D. Poultry

1. Chicken Bacteriological evaluations were made of whole and cut-up chickens shipped in corrugated paper shipping containers and virebound crates. Numbers of mesophilic and psychrophylic bacteria on poultry in corrugated paper containers were similar to those on poultry packed in wirebound crates after shipping about 150 miles and storage at 34° F. for 12 hours. Lining either the inside or coating the outside of a corrugated container with aluminum improved the container's insulating properties only slightly. Use of a kapok liner was more effective for inhibiting heat transfer.

Work on this project was terminated because of the unavailability of corrugated fiber containers which can stand up under laboratory storage tests.

2. Eggs. Microbiological and chemical studies of shell eggs held in cold storage for various periods of time were carried out under a P. L. 480 grant.

Results obtained indicate that shell eggs stored at 0° C. and 90% relative humidity for periods up to 60 days were contaminated primarily with yeasts and molds, with no evidence to indicate the presence of bacteria. In accelerated deterioration tests it was found that (a) the rate of thinning of buffered egg white (pH7) was greater than that of unbuffered, (b) viscosity of egg white decreased with time concomitantly with an increase in the percentage of thin white, these changes being more pronounced in buffered samples, (c) lysozyme activity was higher in buffered eggs than in unbuffered, (d) lysozyme activity decreased slightly with time, and (e) two zones of maximum lysozyme activity appear (pH6 and pH8.4).

E. Vegetables

1. Onions. Onions held 3 weeks in common storage (daily temperature maxima between 77° and 95°F.) before transfer to cold storage (32°) had more physiological breakdown after 4 to 7 months' storage than onions placed in cold storage immediately after harvest. The percentages of affected bulbs in lots cooled immediately and after delay were, respectively, 0 and 4.5% after 4 months, 1 and 7% after 5 months, 12 and 28% after 6 months, and 29 and 39% after 7 months. Large bulbs were more affected than medium or small-sized ones. Onions grown on mineral soil or peat soil were about equally susceptible to this breakdown. Shading of the bulbs during growth in peat soil had no effect on the incidence of the disorder.

Higher than normal amounts of CO_2 in the storage atmosphere (at 32°F.) caused an injury indistinguishable from physiological breakdown. After 5 months, 4.2% of the bulbs held in normal air were affected, whereas in the following atmospheres: 5% CO_2 and 5% O_2; 5% CO_2 and 15% O_2; and 10% CO_2 and 15% O_2 breakdown developed to the extent of 11.1, 8.6, and 93.1%, respectively.

2. Sweetpotatoes. Tests in North Carolina with CIPC, applied as a dip or aerosol, effectively controlled sprouting of sweetpotatoes at ambient storage temperatures (55 to 65°F.) and at elevated temperatures (70° to 80°F.).

Several commercial packinghouses in North Carolina and Georgia installed the SOPP (sodium o-phenylphenate tetrahydrate) treatment, developed during the course of this project, for the control of soft rot during marketing. A simplified test for determining concentration was developed and successfully used by packinghouse operators. In four test shipments of cured roots from eastern North Carolina to New York, N. Y., or Chicago, Illinois, commercially treated roots developed 66 to 75 percent less decay than comparable non-treated roots after 1 week in the market. The average reduction in decay was 7.5 pounds per 100 pounds shipped or about 37 bushels per 500 bushel load. At $5 a bushel this amounts to $185 per load.

Much of the decay in bushel baskets occurs just below the lid as a result of abrasion. Decay in the top of the basket was reduced about 33% by treating the lid with SOPP and about 50% by using excelsior lid cushions.

Additional screening tests in North Carolina verified that Botran (2:6-dichloro-4-nitroanaline) effectively controlled soft rot but is relatively ineffective against black rot. Warm water treatments (100 to 140°F. for 1 to 7 minutes) reduced soft rot but caused surface discolorations on some varieties at effective combinations of temperature and time. The best control of soft rot was obtained with a combination of heat and SOPP.

The effect of three treatments on the keeping quality of Jersey Orange sweetpotatoes in bulk ½-bu. cartons, in 3-pound polyethylene mesh (Vexar) bags, and in perforated polyethylene film bags was determined at Beltsville. The test was conducted in March after the roots had been in storage several months. Rhizopus decay was significantly reduced in the consumer bags by each of the treatments: a 30-second dip in SOPP, a 30-second dip in Botran (2,6-dichloro-4-nitroaniline), and a 3-minute dip in 120°F. water. None of the treatments injured

the sweetpotatoes. Perforated polyethylene bags (32 ¼-inch holes) reduced weight loss by about 1/3 as compared to mesh bags or corrugated cartons.

Now that an effective method for control of decay has been developed and approved for use, it is possible to prepackage sweetpotatoes. This has been impractical heretofore because of decay.

3. Tomatoes. Tests were initiated to develop standards for predetermining ripening rate of tomatoes. "Turning" and "pink" tomatoes, sorted into 6 classes with the Agtron Model F photoelectric instrument, were ripened at 58°, 65°, and 70°F. Tomatoes having similar Agtron readings when just breaking color ripened uniformly to full color.

Mature-green tomatoes breaking color in 1, 2-3, or 4-10 days after arrival at market completed ripening at approximately the same rate (from the time of color break), and reached the same intensity of color when ripe.

Pre-storage color standards were determined objectively for tomatoes to be ripened at 58°, 65°, or 70°F. These will insure uniformly ripened fruit in 4 to 12 days.

Fully-ripened tomatoes lost color and firmness when stored for prolonged periods at 33°-35°F. Such tomatoes remained edible for 3-4 weeks, however, when used directly from cold storage.

A study was made to determine if overfilling of shipping containers causes bruising of mature green tomatoes. Bruising in tomatoes on arrival and after ripening at terminal markets was compared in containers filled to their rated capacity with that occurring in containers filled 2 to 3 pounds below or 2 to 3 pounds above their rated capacity.

In the test shipment from Florida to Washington, D. C., objectionable bruising was least in underfilled wirebound crates and greatest in overfilled ones. In tests from Florida to New York, there were no differences attributable to amount of fill in the three types of packages used. Likewise in the test from Texas to Chicago net weight had no effect on degree of bruising in wirebound crates.

Most bruising occurred in tomatoes that were ripe or pink when unloaded.

Tests were made at Beltsville on the effect of cooling and holding temperatures on ripening of tomatoes harvested when showing 10 to 15, 20 to 30, and 30 to 45 percent red color. Following 4-day holding periods at 60°, 55°, and 50°F. the tomatoes were ripened at 70° and the quality of red color was determined. Tomatoes showing 30 to 45 percent color at harvest needed to be cooled quickly and transported at about 50° to control ripening. Fruits with less than 30 percent color benefited by moderate temperatures of 55° and 60° during the 4-day simulated transit period. For example, tomatoes harvested at 10 to 15 percent color and held at 60° for 4 days were near the stage of ripeness of those harvested at 30 to 45 percent color and held 4 days at 50°. The tomatoes harvested at all three stages of maturity ripened satisfactorily at 70°.

4. Asparagus. Two insulated master containers, each holding 200 pounds of precooled, prepackaged early asparagus, were shipped from Stockton, California to New York via jet air liner. Transit temperatures were between 50 and 64°F. principally because of warming during delays after hydrocooling. Arrival condition was satisfactory, in spite of the high temperatures, because of the short transit period involved. The atmospheres within the two relatively tight containers were modified only slightly during shipment.

To determine the effect of modified atmospheres, during transit periods asparagus spears were held at 36°, 41°, and 50°F. in 10, ~~20~~, 30, or 50% CO_2 and 10% or more O_2 for 24 hours, and then in air for 6 days at the same temperatures. The CO_2 treatments were effective in reducing soft rot of the butts to a maximum of 6% with 10% CO_2, and to negligible amounts at 30% or more CO_2 as compared with 16, 31 and 37% at 36°, 41° and 50°, respectively in untreated spears. However, other injury occurred at the higher concentrations of CO_2. At 20% CO_2 or below no injury was evident. Benefits from a short exposure to CO_2 might be particularly useful in air shipments.

5. Dry Beans. Details of a study on the effect of transit conditions during shipment from the Great Lakes' ports via the St. Lawrence Seaway to Western Europe have been published. One shipment was accompanied and two additional shipments were instrumented to obtain temperature and moisture information at points throughout the ship's hold. Quality measurements were made at origin and at destination. From this study changes in grade and quality of burlap bags and in loading and unloading procedures have been recommended to reduce the excessive physical damage now occurring. The careful use of ship aeration equipment to ventilate holds was recommended so that moisture content of the cargo does not increase during passage from the relatively cool to the warm moist climate encountered in the voyage.

A shipping test program in cooperation with the School Lunch Program (ASCS) and the Multiwall Paper Shipping Sack Manufacturers' Association has been initiated to test the suitability of multiwall kraft 100 pound bags vs. burlap bags now standard for such shipments. Tests to date indicate that the kraft bags are satisfactory for use.

A contract has been made with Agricultural Specialities Company, Hyattsville, Md. to construct a prototype, portable, battery-operated, multipoint-temperature recording device which will operate unattended for periods of up to two weeks. It is designed primarily for use in transportation tests.

6. Brussels Sprouts. The keeping quality of vacuum cooled and hydrocooled prepackaged and bulk Brussels sprouts was compared during simulated transit and marketing periods. Vacuum cooling reduced the temperature of the sprouts to 40°F. and could be done after packaging. Hydrocooling had to be done before packaging because the package prevented adequate contact with the water.

Salability of all lots of sprouts was rated "good" or better after 8 days at 34°F., but the lots that were vacuum cooled without pre-wetting were slightly more wilted than those that were wet before vacuum cooling, or those that were hydrocooled. Top ice helped maintain freshness of the sprouts, especially in the non-packaged lots.

All lots deteriorated somewhat during the additional 2-day period at 70°F. However, the hydrocooled lots retained the freshest appearance and the lots vacuum cooled dry were the most wilted.

7. Cantaloups. Western-grown cantaloups are usually shipped under Standard Refrigeration with full-bunker icing. This refrigeration service was compared to half-stage Standard Refrigeration and a modified full-bunker service using 1 re-icing for cars shipped to Chicago and 2 re-icings for cars shipped to New York. The results showed that Standard Refrigeration, full-bunker icing was not needed. Less costly services provided adequate refrigeration for precooled cantaloups. Half-stage Standard Refrigeration or modified full-bunker refrigeration with 2 re-icings would save the industry $35.19 and $19.77 per car, respectively, over the conventional service for cantaloups shipped from California to New York. Half-stage Standard Refrigeration would save $29.88 and the modified service with 1 re-icing would save $36.50 per car for shipments to Chicago.

Precooling cantaloups by conventional methods is impractical with some of the new containers for melons. The half-cooling times for cantaloups were determined for each of the methods commonly used for melons in wooden crates. Knowing the half-cooling time, a shipper can calculate the time required to cool cantaloups from any initial temperature to any desired temperature. The half-cooling time for cantaloups precooled with top ice and fans in the car was 3 hours; that for melons cooled in a tunnel by forced air was 1-1/4 hours; and that for hydrocooled melons was 1/3 hour. Cooling by any of these methods is fast enough to be practical for commercial handling of crate-packed cantaloups. The half-cooling time for cantaloups packed in cartons and precooled in the car by forced air varied from 2 to 12 hours, depending on the method of loading and the position in the load. Cooling carton-packed melons by this method was usually too slow to be practical for commercial operations.

The market quality of hydrocooled and air-cooled melons was about equal after a simulated transit period at low temperature and a marketing period at room temperature. Cracking of melons was negligible in a commercial hydrocooler. Cantaloups did not absorb water during hydrocooling. However, weight-loss was slightly greater in room-cooled than in hydrocooled melons during subsequent holding.

Cantaloups that were initially above 90°F., generally deteriorated more rapidly than those that were initially about 70°, even though both lots were cooled to and held at the same temperature.

Sodium ortho-phenylphenate (1000 ppm) or calcium hypochlorite (200 ppm), added to the cooling water, reduced surface mold materially.

8. Lettuce.

Vacuum Cooling. Temperature reduction in carton-packed lettuce was improved by lowering the pressure in the tank below the 4.6 mm Hg. level normally used. Evacuation to pressures as low as 3.8 mm Hg. was safe when the time and pressure were properly controlled. Final lettuce temperatures near 32°F. are necessary to maintain quality. For the precise control of pressure in the chamber to prevent freezing at this level, a dial-type high vacuum gage was more reliable than the wet-bulb and "pulp" thermometers now used for control purposes. Thermocouples to measure the temperature of the cooling coils in tanks employing mechanical vacuum pumps were also helpful in achieving better control of cooling. Ammonia pressure gages on the suction line from the coils did not indicate the true temperature of the cooling coils, the temperature at which water vapor from the lettuce was condensed. Lettuce cooling was similar throughout the length of the vacuum tanks tested. However, lettuce

cooled slightly slower in cartons in the middle layer of solid loads than in more exposed locations. These results suggest the desirability of more open placement of cartons on the pallets or in rail cars and truck trailers to be vacuum cooled.

Post-Harvest Handling. Delays between harvest and vacuum cooling are considered in new grades for lettuce. In one test in California a delay of 9-1/2 hours at about 70°F. caused lettuce to have about twice as much decay as delays of 2 or 5 hours. The differences due to delay were small when lettuce was held at 35° instead of 41°. In two other tests under similar conditions no such differences occurred.

Lettuce cooled 6 hours after harvest showed significantly more pink rib than lettuce cooled after only 1-1/2 hours.

Lettuce vacuum cooled to 38°F. and held 8 days at 38° (frequent commercial practice) had more russet spotting and decay than lettuce either cooled to 34° and held at 34° (desired practice) or packed in ice and held under top ice. After an additional 4 days at 50° twice as many heads with decay occurred in lettuce previously held at 38° or packed in ice than lettuce held at 34°.

9. Fresh Peas. In cooperation with T.&F.R.D. tests were made to determine transit temperatures and breakage of bushel tub baskets when fresh California peas are iced with various amounts of top-ice. Peas are usually top-iced at shipping point with ice crushed from 80 blocks (24,000 pounds). This amount was compared to initial top-ice from 40 to 55 blocks plus half-stage bunker ice at the first regular icing station and one retop-icing in transit. All cars were loaded in the conventional manner, 5 high x 6 wide with baskets alternately inverted crosswise and lengthwise through the car. The baskets were loaded with tops to tops and bottoms to bottoms. Previous tests showed that modifications to secure a more solid load reduced rate of cooling.

Commodity temperatures were essentially the same with either icing practice, averaging about 37°F. Container damage data have not yet been evaluated. In most cars very little (0-2 inches) top-ice remained on the load near the bunker fans at destination. The thickest layer of top-ice was generally near the doorway.

10. Liquid Nitrogen as a Refrigerant. The refrigerator car lines and the producers of liquid nitrogen requested information on the biological effects that high nitrogen concentrations might produce in fresh commodities during transit with liquid nitrogen as a refrigerant.

In preliminary tests in California simulating transit conditions, no significant difference in wilting or weight-loss was found between lettuce held under liquid nitrogen refrigeration or that stored in a cold room at about the same temperature. Liquid nitrogen reduced the oxygen level from a normal 21 percent to a range of from 5.4 to 8.5 percent. No injury from reduction of oxygen to this level was found when the lettuce was examined immediately after storage, or after a simulated marketing period. Freezing occurred in lettuce in the top layers of the load and in other positions exposed to the direct stream of nitrogen. Shortening the release cycle, re-positioning the thermostat, or improving the distribution of the gas, may eliminate freezing.

Tests were initiated in Texas to determine the tolerance of fresh commodities to low oxygen concentrations, such as might occur with liquid nitrogen refrigeration. Carrots and tomatoes were stored at recommended transit temperatures up to 10 days in nitrogen with oxygen concentrations of 2-1/2% without undesirable effects.

11. Detection and Description of Freezing Injury of Fresh Vegetables. Symptoms of freezing injury were studied in 14 vegetables. The most common symptom of freezing in green onions, radishes, lima beans, green beans, peppers, cucumbers, squash, bulb onions and turnips was watersoaking. Usually it appeared first on the outer surface of the vegetable as small, more or less circular, abnormally darkened spots. As the freezing progressed the spots gradually coalesced until the entire surface was affected. Internally, frozen areas were generally translucent in appearance rather than opaque. In some instances, particularly with lightly or moderately frozen green beans and turnips, the watersoaking disappeared during thawing.

Internal or external darkening was found to be a symptom of freezing injury in sweet potatoes, carrots, and beets.

Internal or external cracking characterized freezing injury in beets and carrots. Caused by the formation of ice crystals, the small cracks tended to close as the ice melted but, even after complete thawing, the cracks could easily be observed with the use of a microscope.

Pitting was commonly found in peppers, eggplants and radishes after freezing and thawing.

Flabbiness or shrinking due to substantial loss of moisture was observed in parsnips, carrots, peppers, cucumbers and green beans that has been frozen and thawed.

In general, thawing at 40°F. resulted in less damage to the product than thawing at 70°.

F. Potatoes

1. Influence of Storage Temperature on Processing Quality of Potatoes. Twenty-four 1 ton capacity boxes were filled at East Grand Forks, Minnesota, with Irish Cobbler, Kennebec, Red Pontiac and Snowflake potatoes. Equal quantities of each variety were stored at 40°, 45°, and 50° F. The potatoes stored at 45° and 50° were treated with isopropyl N-(3 chlorophenyl) carbamate (CIPC) to inhibit sprouting. At monthly intervals for 10 months, 300-lb. lots were removed from storage for pilot-plant processing into potato flakes and slices. The data on quality of the products are not yet available.

2. Effect of Methods and Rates of Ventilation on Quality of Maine Potatoes. Maine potatoes stored with no forced air circulation for 154 days at 38° F., and 85 percent relative humidity lost approximately 6 1/2 percent in weight. Maintaining the same temperature and humidity at an air flow of 8 fpm increased weight loss to about 8 1/2 percent. By increasing the humidity to 95 percent the weight loss at 8 fpm was about 7 percent.

Instrumentation is being developed, in cooperation with the University of Maine, to measure low airflow velocities which occur within a bin of potatoes. Preliminary tests with the instrument show that most of the air flows along the outer edges of the bin and little air is actually forced through the top center of the pile even at relatively high input rates.

3. Mechanical Injury Incident to Sizing Potatoes into Storage. In the Red River Valley, more bruising occurred in Norland potatoes sized into storage than those not sized but the bruising was largely confined to non-grade defects. About twice as many non-grade defects occurred in the sized potatoes as in unsized. As expected, potatoes in the two larger size groups had about two to three times as many non-grade defects as the small size group.

4. Deep Bin vs. Pallet Box Storage. Although data on weight losses and temperatures indicated relatively slight differences between the two systems, more total bruising resulted in deep bin storage than in pallet box storage in Maine. Approximately 9.6 percent of the tubers from the deep bin were classified as being damaged (5-10 percent waste) whereas only about 5 percent of the tubers in the pallet

box were damaged. Serious damage (over 10 percent waste) was evident in 2 percent of the tubers from the bin whereas about 1 percent of the potatoes in the pallet boxes showed this condition.

Storage of potatoes in pallet boxes reduced the amount of pressure bruising and internal black spot as compared with potatoes stored in deep bins. In samples from deep bins approximately 14.5 percent of the potatoes had pressure bruised areas whereas in pallet boxes 7.7 percent of the potatoes showed this condition. After a holding period of 10 days, 1.1 percent of the potatoes from deep bin storage had developed internal black spot. None of the potatoes from pallet boxes had developed internal black spot.

5. Internal Sprouting. Tests were initiated at Beltsville in April 1961 to determine the causes of the serious losses associated with internal sprouting of potatoes during the 1960-61 season. Maine-grown Katahdin potatoes previously stored at 40° F. were treated with varying concentrations of isopropyl N-(3 chlorophenyl) carbamate (CIPC) in aerosol form. The amount of internal sprouting decreased as the concentration of CIPC was increased and the untreated check lots held at the same temperatures as treated samples had more internal sprouting than treated lots. Storage temperature was the most important factor in the development of internal sprouting. The percentage of tubers with internal sprouting after 5 months' storage at different temperatures were 50° - 1.5%, 60° - 14.4%, 70° - 9.8%.

Three varieties tested during the 1961-62 season showed a widely different response. Irish Cobbler samples had considerably more internal sprouting and averaged 31% in the untreated lots stored at 60° F. as compared to 13% for Kennebec and 7.5 % for Katahdin. Further tests with storage temperatures using the Katahdin variety showed the following percentages of internal sprouting: 50° - none, 55° - 0.3%, 60° - 13.6%, 65° - 19.6%, and 70° - 10.0 %.

In tests the first year potatoes treated with CIPC after sprouting had started, had slightly higher percentages of internal sprouting but differences were not significant the second year. Samples receiving two aerosol applications of CIPC about 2 weeks apart had somewhat less internal sprouting than those receiving only one application. Potatoes dipped in 0.5% suspension of CIPC did not develop internal or external sprouts during 5 or 6 months of storage.

6. Transit Temperatures of California Potatoes for Chipping. Early-season unwashed Kennebec potatoes shipped by rail from California to midwestern chip plants are usually shipped with vents open and no ice,

unless potato temperatures at loading are extremely high. A shipment in which initial temperatures were 75° F. encountered average outside air temperatures of 90° maximum and of 63° minimum enroute. Average potato temperatures in transit were 68° when the vents were partly open (vents on irons) and 67° when the vents were fully open. The color of chips made with potatoes from both cars at arrival was good. Decay was negligible.

A shipment of washed potatoes that had a temperature of 95° at loading was iced with 1 ton of ice in each bunker and shipped with vents open. This shipment encountered average maximum and minimum temperatures of 93° and 64°, respectively. Although the average transit temperature (71°) of the potatoes was satisfactory, decay was excessive (65 to 68%), probably due to the high initial temperature and high moisture conditions resulting from washing.

Chip color, in relation to transit temperatures, was studied in the laboratory. Kennebecs held at 70° F. for simulated transit periods yielded chips with optimum color. Holding at 75° did not improve color and increased the amount of surface mold. Chips made from tubers held at 65° showed significant darkening and those from tubers held at 60° were so dark that they were on the borderline of acceptability.

7. Effect of Low Temperatures on Seed Potatoes. The seed value of four varieties of potatoes, exposed to freezing or near freezing temperatures, was tested in plantings in Maine, New York, and Delaware. Red Pontiac seed potatoes from East Grand Forks, Minnesota, and Katahdin, Irish Cobbler and Pungo seed potatoes from Aroostook County, Maine, were stored and treated at Beltsville, Maryland. All potatoes were stored at 40° F. before treatment and were held at 50° for 2 weeks after treatment before planting. Treatments were: (1) 40° F. continuously (standard), (2) 30° one day, (3) 30° ten days, (4) 25° F. one day (supercooled without freezing), and (5) 25° F. one day (with freezing symptoms produced by jarring).

Unless freezing (with visible symptoms) occurred in the seed tubers, freezing or near-freezing temperatures for up to 10 days did not adversely affect emergence, growth, or yields. This work has been completed.

G. Cut Flowers

1. Shipping Tests with Cut Flowers. Temperatures of cut flowers shipped by air from California to eastern and southeastern markets were mostly in the 50° to 70°F. range, but some summer flower temperatures were as high as 90° and some winter temperatures as low as 34°

Total period from packing to delivery ranged from 18 to 35 hours and averaged 25 hours in the 1961-62 season. In shipments to eastern markets (New York, N. Y. and Washington, D. C.) an average of about 32 percent of this time was spent before departure, 29 percent on the plane, and 39 percent between arrival at the eastern terminal and delivery to the wholesaler. In shipments to the Southeast (Orlando, Fla.) about 25 percent of the time from packing to delivery was spent before departure, 30 percent on the plane, 21 percent at transfer points, and 24 percent after arrival at the terminal.

Variations in transit temperatures and length of transit period were demonstrated to affect flower quality, particularly the opening of rose buds, decay of stocks, chrysanthemums, and asters, as well as many less tangible quality factors. Transit temperatures were lower and more constant in a "bunker" type carton than in a conventional carton. In the bunker carton ice is placed at each end and space is provided for convection of cold air within the container. Transit temperatures also varied considerably among flowers shipped simultaneously by different routes. These results indicate that improved packaging and lower transit temperatures would reduce deterioration and extend the display life of cut flowers.

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